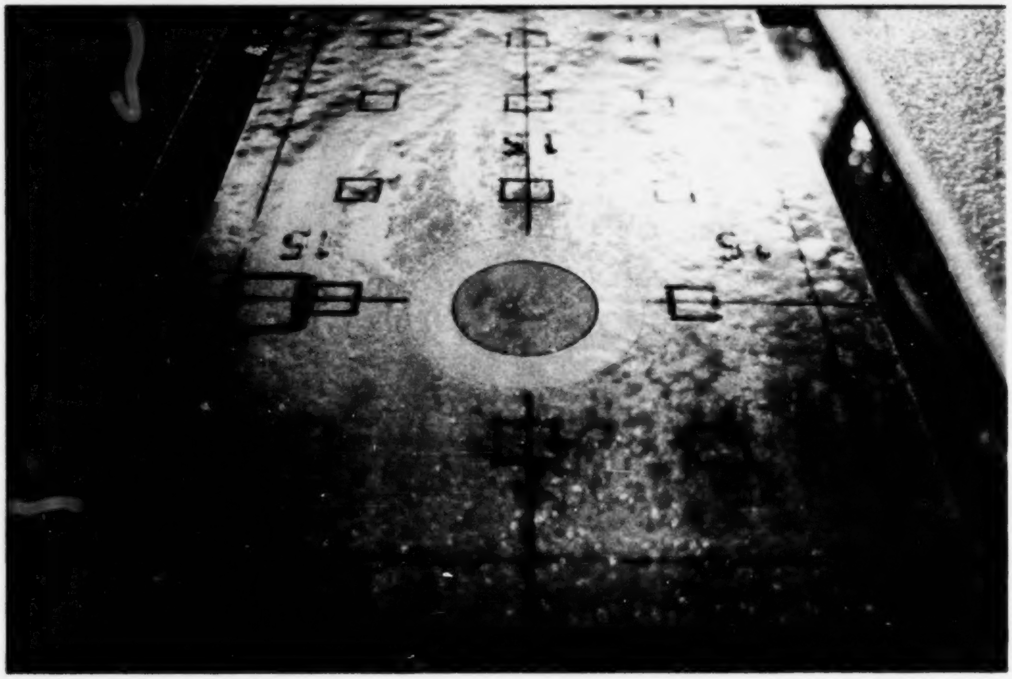
TP 13477E

Aircraft Ground De/Anti-Icing Fluid Holdover Time Field Testing Program for the 1998-99 Winter



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and

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APS AVIATION INC.

October 1999

Final Version 1.0

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by

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Un sommaire français se trouve avant la table des matières.

PREFACE

At the request of the Transportation Development Centre of Transport Canada, APS Aviation Inc. has undertaken a research program to advance aircraft ground deicing/anti-icing technology. The specific objectives of the APS test program are the following:

- To develop holdover time tables for new anti-icing fluids, and to validate fluid-specific and SAE holdover time tables;
- To gather enough supplemental experimental data to support the development of a deicing-only table as an industry guideline;
- To examine conditions for which contamination due to anti-icing fluid failure in freezing precipitation fails to flow from the wing of a jet transport aircraft when subjected to speeds up to and including rotation;
- To measure the jet-blast wind speeds developed by commercial airliners in order to generate air-velocity distribution profiles (to predict the forces that could be experienced by deicing vehicles), and to develop a method of evaluating the stability of deicing vehicles during live deicing operations;
- To determine the feasibility of examining the surface conditions on wings before takeoff through the use of ice-contamination sensor systems, and to evaluate the sensitivity of one ice-detection sensor system;
- To evaluate the use of warm fuel as an alternative approach to ground deicing of aircraft;
- To evaluate hot water deicing to determine safe and practicable limits for wind and outside ambient temperature;
- To document the appearance of fluid failure, to measure its characteristics at the point of failure, and to compare the failures of various fluids in freezing precipitation;
- To determine the influence of fluid type, precipitation (type and rate), and wind (speed and relative direction) on both the locations and times to fluid failure initiation, with special attention to failure progression on the Bombardier Canadair Regional Jet and on high-wing turboprop commuter aircraft;
- To evaluate snow-weather data from previous winters to identify a range of snow-precipitation suitable for the evaluation of holdover time limits;
- To compare the holdover times from natural and artificial snow tests and to evaluate the functionality of the NCAR simulated snowmaking system; and
- To develop a plan for implementing a full-scale wing test facility that would enable the current testing of deicing and anti-icing fluids in natural and artificial freezing precipitation on a real aircraft wing.

The research activities of the program conducted on behalf of Transport Canada during the 1998-99 winter season are documented in twelve reports. The titles of these reports are as follows:

- TP 13477E Aircraft Ground De/Anti-Icing Fluid Holdover Time Field Testing Program for the 1998-99 Winter;

- TP 13478E Aircraft Deicing Fluid Freeze Point Buffer Requirements for Deicing Only Conditions;
- TP 13479E Contaminated Aircraft Takeoff Tests for the 1998-99 Winter;
- TP 13480E Air Velocity Distribution Behind Wing-Mounted Aircraft Engines;
- TP 13481E Feasibility of Use of Ice Detection Sensors for End-of-Runway Wing Checks;
- TP 13482E Evaluation of Warm Fuel as an Alternative Approach to Deicing;
- TP 13483E Hot Water Deicing of Aircraft;
- TP 13484E Characteristics of Failure of Aircraft Anti-Icing Fluids Subjected to Precipitation;
- TP 13485E Aircraft Full-Scale Test Program for the 1998-99 Winter;
- TP 13486E Evaluation of Snow Weather Data for Aircraft Anti-Icing Holdover Times;
- TP 13487E Development of a Plan to Implement a Full-Scale Test Site; and
- TP 13488E A Snow Generation System – Prototype Testing

This report, TP 13477E, addresses the following objective:

- To develop holdover time tables for new anti-icing fluids, and to validate fluid-specific and SAE holdover time tables.

This objective was met by conducting holdover time tests on different fluids in simulated freezing precipitation at the National Research Council Canada Climatic Engineering Facility in Ottawa, and by carrying out tests in natural snow conditions at a test facility operated by APS at Dorval Airport in Montreal.

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16. Abstract

The primary objective of the 1998-99 holdover time test program was to evaluate the performance of new and previously qualified Type IV fluids over the entire range of conditions encompassed by the holdover time tables, using fluid samples representative of the manufacturer's lowest recommended on-wing viscosity. Additional tests were also conducted with Type I and Type II fluids, as well as a reference fluid. An evaluation of anti-icing fluid thickness was performed for all fluids used in holdover time testing. Additional tests were also performed in order to evaluate the holdover time and compatibility performance of recycled fluids. The effect of fluid viscosity on the holdover time of anti-icing fluids was also studied.

The holdover time test procedure consisted of pouring fluids onto clean aluminium test surfaces inclined at 10°; the onset of failure was recorded as a function of time in natural snow and simulated freezing fog, freezing drizzle, light freezing rain, and rain on a cold-soaked wing conditions. Type IV fluids supplied by Clariant, Kilfrost, Octagon, SPCA, and Union Carbide were tested in neat and diluted forms. Type II fluid was supplied by Kilfrost. Type I fluids were supplied by Clariant, Home Oil, Inland, Jarchem, Kilfrost, Octagon and Union Carbide. Over 1500 holdover time tests were performed either at the APS Dorval Airport test facility in Montreal or at the National Research Council Canada Climatic Engineering Facility in Ottawa.

De/anti-icing fluid holdover times were determined using a multi-variable regression analysis, resulting in the generation of one generic SAE Type IV fluid table, and six fluid-specific Type IV fluid tables. A fluid-specific table for Type II Kilfrost ABC-II Plus was also developed and accepted by the Society of Automotive Engineers, Inc. (SAE) G-12 Holdover Time Sub-Committee. Thickness profiles of the Type IV fluids were similar to those observed in 1997-98 trials. Recycled fluids performed similar to Type I fluids in holdover time and fluid compatibility trials.

17. Key Words
Anti-icing, deicing, deicing fluid, holdover times, precipitation

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Les rapports de recherche produits au nom de Transports Canada sur les essais réalisés au cours des hivers antérieurs peuvent être obtenus auprès du Centre de développement des transports (CDT). Le programme de la saison hivernale 1998-1999 a donné lieu à douze rapports (dont celui-ci). On trouvera dans la préface l'objet de ces rapports.

16. Résumé

Le principal objectif du programme d'essais de durée d'efficacité de 1998-1999 était d'évaluer la performance de liquides de type IV déjà ou nouvellement homologués, dans toute la gamme des conditions couvertes par les tableaux des durées d'efficacité, à l'aide d'échantillons de liquides représentatifs de la plus faible viscosité sur l'aile recommandée par le fabricant. Des essais ont aussi été menés avec des liquides de type I et de type II, de même qu'avec un liquide de référence. Tous les essais de durée d'efficacité comportaient la mesure de l'épaisseur de la couche de liquide antigivrage. Des essais complémentaires ont été menés afin d'évaluer la durée d'efficacité et la compatibilité de liquides recyclés. L'effet de la viscosité du liquide sur sa durée d'efficacité contre le givre a aussi été étudiée.

La procédure d'essai consistait à verser les liquides sur des plaques d'essai en aluminium propres, inclinées à 10 degrés, et à noter ensuite l'amorce de la perte d'efficacité en fonction du temps, sous des précipitations de neige naturelle et des précipitations artificielles de bruine verglaçante, de brouillard verglaçant, de pluie verglaçante légère et de pluie sur une aile imprégnée de froid. Les liquides de type IV, fournis par Clariant, Kilfrost, Octagon, SPCA et Union Carbide, ont été essayés purs et dilués. Le liquide de type II était fourni par Kilfrost. Quant aux liquides de type I, ils étaient fournis par Clariant, Home Oil, Inland, Jarchem, Kilfrost, Octagon et Union Carbide. Plus de 1 500 essais ont été réalisés soit à l'installation d'essai d'APS à l'Aéroport de Dorval, à Montréal, soit à l'Installation de génie climatique du Conseil national de recherches du Canada, à Ottawa.

Les durées d'efficacité des liquides de dégivrage/antigivrage ont été déterminées par une analyse de régression multidimensionnelle, et ont mené à la création d'un tableau générique et de six tableaux spécifiques des durées d'efficacité de liquides de type IV. Un tableau spécifique a aussi été élaboré pour le liquide de type II Kilfrost ABC-II Plus et il a été accepté par le sous-comité G-12 sur les durées d'efficacité de la Society of Automotive Engineers, Inc. (SAE). Les profils d'épaisseur des liquides de type IV étaient semblables aux profils observés au cours des essais de 1997-1998. Quant aux liquides recyclés, ils ont affiché une performance semblable à celle des liquides de type I aux essais de durée d'efficacité et de compatibilité.

17. Mots clés
Antigivrage, dégivrage, liquide de dégivrage, durées d'efficacité, précipitation

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EXECUTIVE SUMMARY

At the request of the Transportation Development Centre of Transport Canada and the U.S. Federal Aviation Administration, APS Aviation Inc. has undertaken a research program to further advance aircraft pre-flight de/anti-icing technology. While a number of objectives of the test program are documented in a series of related reports, the primary objective specifically addressed in this document was:

- To develop holdover time tables for new anti-icing fluids and to validate fluid-specific and Society of Automotive Engineers, Inc. (SAE) holdover time tables.

Several supplemental objectives were also addressed: evaluation of the holdover time and compatibility performance of recycled fluids; determination of the effect of fluid viscosity on the holdover time of Type IV fluids; determination of frost deposition rates in natural conditions; and determination of the holdover time performance of a reference fluid.

The project involved the participation of several de/anti-icing fluid manufacturers, the Transportation Development Centre of Transport Canada, National Research Council Canada (NRC), the U.S. Federal Aviation Administration, and the Atmospheric Environment Service (AES) of Canada.

Holdover time tests consist of pouring freezing point depressant fluids onto clean, inclined (10°), standard flat aluminum plates. The plates are mounted on a test stand and systematically exposed to an array of natural or artificially produced icing conditions. The elapsed time required to reach a pre-defined end condition is recorded for every plate. Test end conditions and the test bed specifications adhere to SAE/ISO (Society of Automotive Engineers/International Organization for Standardization) G-12 Holdover Time Subcommittee guidelines.

The variables measured include failure time, type of precipitation, rate of precipitation, total precipitation, visibility, wind speed, wind direction, ambient temperature, test surface temperature, fluid brand, fluid type, and fluid concentration.

Data Collection

During the 1998-99 test season, data were collected for tests conducted during natural precipitation events at the APS Dorval Airport test site. Data were also collected for artificial precipitation tests, which included the following simulated conditions: freezing drizzle, light freezing rain, freezing fog, snow and rain on cold-soaked surfaces. The artificial precipitation tests were performed indoors at NRC's Climatic Engineering Facility (CEF) in Ottawa. The test distribution listed in Table 1 indicates that the majority of the more than 1500 tests were carried out using Type IV fluids in natural snow conditions. The fluid in the "other" category is the reference fluid.

Table 1: Test Distribution

	CONDITION					
Fluid Type	**Natural Snow**	**Freezing Drizzle**	**Light Freezing Rain**	**Freezing Fog**	**Cold Soak**	**Total**
Type I (Standard)	98	32	30	35	10	205
Type I (10°buffer)		32	32	89	32	185
Type II (Neat)	36	10	9	13	4	72
Type II (75/25)	32	8	9	8	4	61
Type II (50/50)	19	4	4	4		31
Type IV (Neat)	219	75	57	72	28	451
Type IV (75/25)	176	38	32	33	16	295
Type IV (50/50)	68	16	16	16	-	116
Other	23	8	8	12	4	55
Total	**671**	**223**	**197**	**282**	**98**	**1471**

In addition, 30 preliminary tests were conducted indoors at NRC in Ottawa, using an artificial snow generation system developed by the National Centre for Atmospheric Research (NCAR).

Meteorological Considerations

With the co-operation of AES, APS was able to obtain detailed meteorological information for the tests at the Dorval site. The data provided by AES instruments were automated and provided minute-by-minute information such as total precipitation, wind speed, wind direction, visibility, and temperature. Precipitation was also collected at the Dorval site using plate pans. Data on rates of precipitation for natural snowfall versus temperature were also collected to assist in the evaluation of precipitation rate limits; this is discussed in Transport Canada report TP 13486E.

Thickness Tests

Thickness measurements were carried out on Type II and Type IV fluid films, and thickness profiles for each fluid brand were plotted as a function of time. The thickness profiles were found to be similar to those observed in thickness tests conducted in 1997-98.

Holdover Time Tests

Holdover time tables were developed for six SAE-qualified Type IV fluids. From the six fluid-specific Type IV fluid holdover time tables, one "generic" or SAE holdover time table, consisting of cells containing the holdover times of the worst-performing fluid, was assembled. For the six fluid-specific Type IV fluid holdover time tables, all categories of precipitation and temperature ranges adopted holdover times that were determined using the regression analysis of the data collected for each specific fluid.

Twenty-six changes were made to the SAE Type IV table, based on the results of tests conducted with low-viscosity fluids. Twelve changes were made to the freezing fog column of the generic Type IV table, some of which were significant. The majority of the changes outside of the freezing fog column were 5-minute reductions.

No Type III fluids were available during the past season and therefore no Type III tests were performed. A Type III holdover time table exists; however, the values need to be substantiated, since the table was generated using a fluid that is no longer commercially available.

No changes were made to the current Type I fluid holdover times, although the upper holdover times in freezing fog may need to be re-adjusted based on the results of tests conducted in 1998-99.

Twenty-two reductions were made to Type II fluid holdover times, due to the results of Type II Kilfrost ABC-II Plus fluid and to the results of the most recent Type IV fluid study. These changes were made to prevent Type II fluid holdover times from exceeding the Type IV SAE fluid table holdover times. Although reducing Type II holdover times based on the results of Type IV tests has become routine, there are those within the SAE G-12 who disagree with this practice.

Supplementary Tests

Recycled fluids were subjected to holdover time and fluid compatibility tests, and demonstrated performance similar to Type I fluids.

The effect of fluid viscosity on holdover time was studied and was deemed to affect the holdover times of anti-icing fluids. In general, high viscosity fluids outperformed low viscosity fluids in holdover time tests.

Frost deposition rates, collected on flat plates, were found to be surface dependent. Standard aluminum surfaces collected no frost whatsoever. The rates of deposition on painted aluminum surfaces ranged from 0.05 to 0.09 g/dm^2/h, depending on colour. Composite surfaces collected frost at rates that varied from 0.07 to 0.19 g/dm^2/h, while an aluminum honeycomb core plate collected frost at 0.04 g/dm^2/h. The heaviest deposition rates were observed in plate pans coated with Type IV fluid (0.12 to 0.25 g/dm^2/h).

Recommendations

Section 8 of this report lists recommendations based on this year's tests and results. The main recommendations were as follows:

- Any new fluids should be tested and evaluated over the entire range of conditions of the holdover time tables; and
- Additional testing should be conducted with the improved NCAR artificial snow generation system.

SOMMAIRE

À la demande du Centre de développement des transports (CDT) de Transports Canada et de la Federal Aviation Administration (FAA) des États-Unis, APS Aviation Inc. (APS) a entrepris un programme de recherche qui vise à faire progresser la technologie de dégivrage et de protection antigivrage des avions au sol. Plusieurs des objectifs assignés à ce programme sont traités dans une série de rapports déjà publiés. Le grand objectif de la présente recherche était le suivant :

- Élaborer des tableaux de durées d'efficacité pour de nouveaux liquides antigivrage et valider les tableaux de durées d'efficacité de la Society of Automotive Engineers, Inc. (SAE).

Plusieurs autres objectifs étaient également poursuivis : évaluer la durée d'efficacité et la compatibilité de liquides recyclés; déterminer l'effet de la viscosité sur la durée d'efficacité des liquides de type IV; déterminer les taux d'accrétion de givre en conditions naturelles; déterminer la durée d'efficacité d'un liquide de référence.

Le projet a réuni plusieurs fabricants de liquides de dégivrage/antigivrage, le CDT de Transports Canada, le Conseil national de recherches du Canada (CNRC), la FAA des États-Unis et le Service de l'environnement atmosphérique (SEA) d'Environnement Canada.

Les essais de durée d'efficacité consistaient à verser les liquides abaisseurs du point de congélation sur des plaques standard propres, en aluminium, inclinées à 10 degrés. Ces plaques étaient montées sur un banc d'essai et systématiquement exposées à diverses formes de précipitations givrantes naturelles et artificielles. Le temps écoulé jusqu'à un état final prédéfini était enregistré pour chaque plaque. Les états finaux indicatifs de perte d'efficacité et les spécifications relatives au banc d'essai étaient conformes aux lignes directrices du sous-comité G-12 de la SAE/ISO (Society of Automotive Engineers/Organisation internationale de normalisation) sur les durées d'efficacité.

Les variables mesurées comprenaient la durée d'efficacité, le type de précipitation, le taux de précipitation, la précipitation totale, la visibilité, la vitesse du vent, la direction du vent, la température ambiante, la température de la surface d'essai, la marque du liquide testé, le type de liquide et la concentration du liquide.

Collecte des données

Les données colligées au cours de la saison hivernale 1998-1999 concernaient des essais sous précipitations naturelles menés à l'installation d'essai d'APS à l'Aéroport de Dorval. Des données ont aussi été recueillies sous des précipitations artificielles qui englobaient de la bruine verglaçante, de la pluie légère verglaçante, du brouillard verglaçant, de la neige et de la pluie sur une aile imprégnée de froid. Les essais sous précipitations artificielles ont été réalisés à l'intérieur, dans l'Installation de génie climatique du CNRC, à Ottawa. Comme l'indique le tableau 1, sur les 1 500 essais et plus, les essais réalisés sous neige naturelle avec des liquides de type IV représentent la proportion la plus importante. Le liquide de la catégorie «autre» est le liquide de référence.

Tableau 1 : Répartition des essais

	PRÉCIPITATION					
Type de liquide	**Neige naturelle**	**Bruine verglaçante**	**Pluie verglaçante légère**	**Brouillard verglaçant**	**Pluie sur aile imprégnée de froid**	**Total**
Type I (standard)	98	32	30	35	10	205
Type I (marge de 10 °)		32	32	89	32	185
Type II (pur)	36	10	9	13	4	72
Type II (75/25)	32	8	9	8	4	61
Type II (50/50)	19	4	4	4		31
Type IV (pur)	219	75	57	72	28	451
Type IV (75/25)	176	38	32	33	16	295
Type IV (50/50)	68	16	16	16	-	116
Autre	23	8	8	12	4	55
Total	**671**	**223**	**197**	**282**	**98**	**1 471**

De plus, 30 essais préliminaires ont été menés à l'intérieur, au CNRC à Ottawa, à l'aide d'un système de fabrication de neige artificielle développé par le National Centre for Atmospheric Research (NCAR) des États-Unis.

Considérations météorologiques

Grâce à la collaboration du SEA, APS a pu obtenir des données météorologiques détaillées pour ses essais au site de Dorval. En effet, les instruments du SEA transmettaient automatiquement, de minute en minute, diverses données, comme la quantité totale de précipitation, la vitesse du vent, la direction du vent, la visibilité et la température. À Dorval, les précipitations étaient aussi mesurées à l'aide de bacs. De plus, les données sur les taux de précipitation de neige naturelle en fonction de la température ont été colligées, aux fins de l'évaluation de taux de précipitation limites (voir le rapport TP 13486E de Transports Canada).

Essais d'épaisseur

L'épaisseur des couches de liquides de type II et de type IV a été mesurée et des courbes de l'épaisseur en fonction du temps ont été tracées pour chaque marque de liquide. Les courbes d'épaisseur obtenues se sont avérées semblables à celles obtenues lors des essais menés en 1997-1998.

Essais de durée d'efficacité

Des tableaux des durées d'efficacité ont été produits pour six liquides de type IV homologués par la SAE. De ces tableaux spécifiques a été dérivé un tableau «générique» de la SAE, qui comprend les durées d'efficacité du liquide le moins performant. Pour chacun des six tableaux spécifiques, les durées d'efficacité correspondant à toutes les catégories de précipitations et plages de températures résultent de l'analyse de régression des résultats obtenus pour chaque liquide individuel.

Vingt-six changements à la baisse ont été apportés au tableau des liquides de type IV de la SAE, d'après les résultats obtenus aux essais de liquides de faible viscosité. Douze modifications, dont certaines importantes, ont été faites dans la colonne «brouillard verglaçant» du tableau générique des liquides de type IV. Mise à part la colonne «brouillard verglaçant», la majorité des changements consistaient à réduire de cinq minutes la durée d'efficacité.

Aucun liquide de type III n'a été essayé car il n'existait aucun liquide de ce type sur le marché en 1998-1999. Il existe bien un tableau des durées d'efficacité des liquides de type III; mais il a besoin d'être validé, car le liquide qui a servi à le produire est disparu du marché.

Aucun changement n'a été apporté aux durées d'efficacité des liquides de type I. Les résultats des essais de 1998-1999 pourraient toutefois rendre nécessaire une révision de la frange supérieure des durées d'efficacité sous brouillard verglaçant.

Vingt-deux durées d'efficacité ont été réduites dans le tableau des liquides de type II, compte tenu des résultats obtenus aux essais du liquide de type II Kilfrost ABC-II Plus et des résultats de l'étude sur le dernier liquide de type IV mis sur le marché. Ces changements visaient à faire en sorte que les durées d'efficacité d'un liquide de type II ne puissent dépasser les durées d'efficacité du tableau de la SAE pour les liquides de type IV. Même s'il est devenu une formalité de réduire les durées d'efficacité des liquides de type II à partir des résultats obtenus aux essais des liquides de type IV, certains membres du sous-comité G-12 de la SAE n'approuvent pas cette pratique.

Essais complémentaires

Des liquides recyclés soumis à des essais de durée d'efficacité et de compatibilité ont affiché des niveaux de performance semblables à ceux des liquides de type I.

Pour ce qui est de l'effet de la viscosité du liquide sur sa durée d'efficacité, tout porte à croire que la viscosité influe sur la durée d'efficacité des liquides antigivrage. En général, les liquides à forte viscosité se sont mieux classés que les liquides à faible viscosité aux essais de durée d'efficacité.

Les taux d'accrétion du givre recueilli sur les plaques planes variaient selon la nature de la surface. Ainsi, aucun givre quel qu'il soit ne se formait sur les surfaces en aluminium standard. Les taux d'accrétion sur les surfaces en aluminium peintes allaient de 0,05 à 0,09 g/dm^2/h, selon la couleur. Sur les surfaces en composite, le taux d'accrétion du givre variait de 0,07 à 0,19 g/dm^2/h, tandis que sur une plaque en aluminium à âme en nid d'abeilles, le givre se formait à un rythme de 0,04 g/dm^2/h. Les taux d'accrétion les plus importants ont été observés dans les bacs revêtus d'un liquide de type IV (0,12 à 0,25 g/dm^2/h).

Recommandations

La section 8 du rapport énumère une série de recommandations inspirées des essais et résultats de cette année. Voici les deux principales :

- que tout nouveau liquide soit testé et évalué dans toute la gamme des conditions couvertes par les tableaux de durée d'efficacité;
- que de nouveaux essais soient menés avec le système de fabrication de neige artificielle amélioré du NCAR.

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GLOSSARY

AES	Atmospheric Environment Service
AMIL	Anti-icing Materials International Laboratory
APS	APS Aviation Inc.
CEF	Climatic Engineering Facility
C/FIMS	Contaminant/Fluid Integrity Monitoring System
EG	Ethylene Glycol
FAA	Federal Aviation Administration (U.S.)
GPM	Gallons Per Minute
HHET	High Humidity Endurance Time
ICAO	International Civil Aviation Organization
IP	Ice-phobic
LOUT	Lowest Operational Use Temperature
MVD	Median Volume Diameter
NASA	National Aeronautics and Space Administration (U.S.)
NCAR	National Center for Atmospheric Research (U.S.)
NRC	National Research Council Canada
PG	Propylene Glycol
POSS	Precipitation Occurrence Sensing System
RAA	Regional Airline Association
READAC	Remote Environmental Automatic Data Acquisition Concept

RPM	Revolutions Per Minute
SAE	Society of Automotive Engineers, Inc.
TDC	Transportation Development Centre (Canada)
WSET	Water Spray Endurance Time
ZD	Freezing Drizzle
ZR	Freezing Rain

1. INTRODUCTION

At the request of the Transportation Development Centre (TDC) of Transport Canada and the U.S. Federal Aviation Administration (FAA), APS Aviation Inc. has undertaken a research project to further advance ground aircraft de/anti-icing technology. This project involved the participation of TDC, Transport Canada, the FAA, and several de/anti-icing fluid manufacturers.

Aircraft ground de/anti-icing has been the subject of concentrated industry attention over the past decade due to the occurrence of several fatal icing-related aircraft accidents. Recent attention has been focused on the enhancement of anti-icing fluids in order to provide an extended period of protection against further contamination following initial deicing. This emphasis has led to the development of de/anti-icing fluid holdover time tables for use by aircraft operators and accepted by regulatory authorities. New anti-icing formulations continue to be developed by leading manufacturers with the specific objective of prolonging fluid holdover times without compromising the aerodynamic features of the airfoil.

Flat plate tests, conducted in natural and simulated precipitation, are used to develop and substantiate fluid holdover time tables for current fluids and new formulations. Test procedures to measure the duration of fluid protection against ice formation have evolved into a refined standard approach that is followed by APS and others at a number of locations.

Aircraft are deiced using heated Type I fluids. These fluids are excellent for the removal of existing contamination on aircraft wings; however, they provide limited protection against further ice accumulation. Anti-icing fluids are applied following aircraft deicing. Type II fluids are thicker and more viscous than Type I deicing fluids. They form a thicker layer on application and provide a longer duration of protection against further contamination. Type III is an anti-icing fluid developed with shear and flow properties designed for aircraft with slower rotation speeds. Type IV fluids are the latest generation of anti-icing fluids and are designed to provide the utmost in holdover time protection. The results of tests conducted during the 1998-99 winter season with fluid Types I, II and IV constitute the major focus of this report. All Type II and Type IV anti-icing fluid tests were conducted using fluid representative of the lowest acceptable on-wing viscosity. Type I fluids were tested in standard dilution form and diluted to a 10° buffer.

Testing of these fluids has resulted in the generation of holdover time tables. These tables provide guidelines for use in departure planning in adverse winter conditions. They provide the holdover time ranges for aircraft treated with any particular qualified deicing or anti-icing fluid.

A new data analysis protocol was developed in 1996-97 wherein the failure data for each fluid brand, for each cell of the holdover time tables, were subject to a multi-variable regression treatment. The new Type IV fluid holdover times, obtained during the 1998-99 test season, were determined using this method of analysis, resulting in the generation of one *generic* or Society of Automotive Engineers, Inc. (SAE) Type IV fluid table and six *fluid-specific* Type IV fluid tables.

Over the past years, APS Aviation has completed substantial testing, on behalf of Transport Canada, related to the determination of fluid holdover times and the substantiation of holdover time tables, as well as to the research and development of deicing technology in general. A summary of the research related to fluid holdover times is provided in Table 1.1.

1.1 Holdover Time Tables

The holdover time tables developed for use in the 1998-99 winter season are shown in Tables 1.2 to 1.4: Table 1.2 is for Type I fluids; Table 1.3 is the *generic* or SAE table for Type II fluids; and Table 1.4 is the *generic* or SAE table for Type IV fluids. These tables contain the fluid holdover times that were provided to operators for use during the 1998-99 winter season. Each holdover time table is composed of cells, and each cell contains a holdover time range that refers to a specific fluid type and dilution, temperature range, and category of precipitation. The time range in each cell is defined by a lower time and an upper time; these values represent the average failure time of the fluid at the upper and lower precipitation rate limits, respectively. These limits are defined in Subsection 2.9 for all categories of precipitation.

The holdover time tables shown in this section were first published in last year's (winter 1997-98) Transport Canada report TP 13318E (1). Analysis of the Type IV data from 1996-97 indicated a need to develop *fluid-specific* holdover time tables in addition to a *generic* or *worst-case* SAE fluid holdover time table. Results of testing in 1997-98 also indicated a requirement for *fluid-specific* holdover time tables and one *generic* holdover time table. The *generic* or SAE table encompasses the performance behaviour of all qualified Type IV fluids. The fluid-specific approach was taken due to wide variations in the performance of the different Type IV fluids tested. The fluid-specific holdover time tables for the seven Type IV fluids – Clariant MPIV 1957, Clariant MPIV 2001, Kilfrost ABC-S, Octagon Max-Flight, SPCA AD-404, SPCA AD-480, and Union Carbide Ultra + – tested during 1997-98, are shown in Tables 1.5 to 1.11.

TABLE 1.1

SUMMARY OF APS HOLDOVER TIME TESTING ACTIVITIES

Year	Transport Canada (TDC) Report #	Conditions Tested	Primary Fluids Tested	Location of Testing
1990-91	TP 11206E	• Natural Precipitation (mostly snow)	Type II (100%)	Mostly Dorval, worldwide
1991-92	TP 11454E	• Natural Precipitation (mostly snow)	Type III	Mostly Dorval, St. John's
1992-93	TP 11836E	• Natural Precipitation (snow) • Simulated Freezing Drizzle (preliminary) • Simulated Freezing Fog (outdoor)	Type I (Standard)	Dorval and Ottawa (NRC)
1993-94	TP 12915E (Summary Report)	• Natural Precipitation • Simulated Freezing Drizzle • Simulated Light Freezing Rain • Simulated Freezing Fog (outdoor)	Type II (75/25, 50/50)	Dorval and Ottawa (NRC)
1994-95	TP 12654E	• Natural Precipitation • Simulated Freezing Drizzle • Simulated Light Freezing Rain • Simulated Freezing Fog (indoor) • Rain on a Cold-Soaked Surface (preliminary)	• Type I (Diluted for 10ºC buffer) • Type IV (Preliminary)	Dorval and Ottawa (NRC)
1995-96	TP 12896E	• Natural Precipitation • Simulated Freezing Drizzle • Simulated Light Freezing Rain • Simulated Freezing Fog (indoor) • Rain on a Cold-Soaked Surface	Type IV	Dorval and Ottawa (NRC)
1996-97	TP 13131E	• Natural Precipitation • Simulated Freezing Drizzle • Simulated Light Freezing Rain • Simulated Freezing Fog (indoor) • Rain on a Cold-Soaked Surface	• New Type IVs • Type III	Dorval and Ottawa (NRC)
1997-98	TP 13318E	• Natural Precipitation • Simulated Freezing Drizzle • Simulated Light Freezing Rain • Simulated Freezing Fog (indoor) • Rain on a Cold-Soaked Surface	• New Type IVs	Dorval and Ottawa (NRC)
1998-99	TP 13477E	• Natural Precipitation • Simulated Freezing Drizzle • Simulated Light Freezing Rain • Simulated Freezing Fog (indoor) • Rain on a Cold-Soaked Surface • Simulated Snow	- Low Viscosity Type IVs - Type II - Type I	Dorval and Ottawa (NRC)

TABLE 1.2

SAE TYPE I HOLDOVER TIMES

For Use in 1998-99

OAT		Approximate Holdover Times Under Various Weather Conditions (hours:minutes)					
°C	°F	*FROST	FREEZING FOG	SNOW	**FREEZING DRIZZLE	LIGHT FRZ RAIN	RAIN ON COLD SOAKED WING
above 0°	above 32°	0:45	0:12-0:30	0:06-0:15	0:05-0:08	0:02-0:05	0:02-0:05
0 to -10	32 to 14	0:45	0:06-0:15	0:06-0:15	0:05-0:08	0:02-0:05	
below -10	below 14	0:45	0:06-0:15	0:06-0:15			

- * During conditions that apply to aircraft protection for ACTIVE FROST.
- ** Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.

TABLE 1.3

SAE TYPE II HOLDOVER TIMES

For Use in 1998-99

OAT		SAE Type II Fluid Concentration Neat-Fluid/Water (Vol%/Vol%)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)					
°C	°F		*FROST	FREEZING FOG	SNOW	***FREEZING DRIZZLE	LIGHT FRZ RAIN	RAIN ON COLD SOAKED WING
above 0°	above 32°	100/0	12:00	1:15-3:00	0:20-1:00	0:30-1:00	0:15-0:30	0:10-0:40
		75/25	6:00	0:50-2:00	0:15-0:40	0:20-0:45	0:10-0:25	0:05-0:25
		50/50	4:00	0:20-0:45	0:05-0:15	0:10-0:20	0:05-0:10	
0 to -3	32 to 27	100/0	8:00	0:35-1:30	0:20-0:45	0:30-1:00	0:15-0:30	
		75/25	5:00	0:25-1:00	0:15-0:30	0:20-0:45	0:10-0:25	
		50/50	3:00	0:15-0:45	0:05-0:15	0:10-0:20	0:05-0:10	
below -3 to -14	below 27 to 7	100/0	8:00	0:35-1:30	0:15-0:40	**0:30-1:00	**0:10-0:30	
		75/25	5:00	0:25-1:00	0:15-0:30	**0:20-0:45	**0:10-0:25	
below -14 to -25	below 7 to -13	100/0	8:00	0:20-1:30	0:15-0:30			
below -25	below -13	100/0	SAE TYPE II fluid may be used below -25°C (-13°F) provided the freezing point of the fluid is at least 7°C (13°F) below the OAT and the aerodynamic acceptance criteria are met. Consider use of SAE Type I when SAE Type II fluid cannot be used.					

- * During conditions that apply to aircraft protection for ACTIVE FROST.
- ** The lowest use temperature is limited to -10°C (14°F).
- *** Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.

TABLE 1.4

NEW SAE TYPE IV 1998-99 HOLDOVER TIMES

SAE

OAT		Type IV Fluid Concentration	Approximate Holdover Times Anticipated Under Various Weather Conditions (hours:minutes)					
°C	°F	Neat-Fluid/Water (% by volume)	*FROST	FREEZING FOG	SNOW	***FREEZING DRIZZLE	LIGHT FRZ RAIN	RAIN ON COLD SOAKED WING
above 0°	above 32°	100/0	18:00	2:00-3:00	0:45-1:25	0:40-1:00	0:35-0:55	0:10-0:50
		75/25	6:00	1:05-2:00	0:20-0:40	0:30-1:00	0:15-0:30	0:05-0:35
		50/50	4:00	0:20-0:45	0:05-0:20	0:10-0:20	0:05-0:10	
0 to -3	32 to 27	100/0	12:00	2:00-3:00	0:35-1:00	0:40-1:00	0:35-0:55	
		75/25	5:00	1:05-2:00	0:20-0:35	0:30-1:00	0:15-0:30	
		50/50	3:00	0:20-0:45	0:05-0:15	0:10-0:20	0:05-0:10	
below -3 to -14	below 27 to 7	100/0	12:00	0:40-3:00	0:20-0:40	**0:25-1:00	**0:15-0:30	
		75/25	5:00	0:30-2:00	0:15-0:25	**0:25-1:00	**0:15-0:30	
below -14 to -25	below 7 to -13	100/0	12:00	0:20-2:00	0:15-0:30			
below -25	below -13	100/0	SAE TYPE IV fluid may be used below -25°C (-13°F) provided the freezing point of the fluid is at least 7°C (13°F) below the OAT and the aerodynamic acceptance criteria are met. Consider use of SAE Type I when SAE Type IV fluid cannot be used.					

* During conditions that apply to aircraft protection for ACTIVE FROST.

** The lowest use temperature is limited to -10°C (14°F).

*** Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.

TABLE 1.5

FLUID-SPECIFIC TYPE IV HOLDOVER TIMES FOR 1998-99

CLARIANT MPIV 1957

OAT		**Type IV Fluid Concentration Neat-Fluid/Water (% by volume)**	**Approximate Holdover Times Anticipated Under Various Weather Conditions (hours:minutes)**					
°C	**°F**		***FROST**	**FREEZING FOG**	**SNOW**	*****FREEZING DRIZZLE**	**LIGHT FRZ RAIN**	**RAIN ON COLD SOAKED WING**
above 0°	**above 32°**	**100/0**	18:00	2:00-3:00	1:05-2:00	0:50-1:40	0:40-1:00	0:10-0:50
		75/25	6:00	1:05-2:00	0:45-1:25	0:45-1:15	0:30-0:40	0:05-0:35
		50/50	4:00	0:20-0:45	0:15-0:30	0:15-0:25	0:10-0:15	
0 to -3	**32 to 27**	**100/0**	12:00	2:00-3:00	0:45-1:25	0:50-1:40	0:40-1:00	
		75/25	5:00	1:05-2:00	0:30-1:00	0:45-1:15	0:30-0:40	
		50/50	3:00	0:20-0:45	0:10-0:20	0:15-0:25	0:10-0:15	
below -3 to -14	**below 27 to 7**	**100/0**	12:00	0:40-3:00	0:30-0:55	**0:55-1:25	**0:30-0:45	
		75/25	5:00	0:30-2:00	0:20-0:40	**0:45-1:15	**0:25-0:35	
below -14 to -25	**below 7 to -13**	**100/0**	12:00	0:20-2:00	0:25-0:45			
below -25	**below -13**	**100/0**	SAE TYPE IV fluid may be used below -25°C (-13°F) provided the freezing point of the fluid is at least 7°C (13°F) below the OAT and the aerodynamic acceptance criteria are met. Consider use of SAE Type I when SAE Type IV fluid cannot be used.					

* During conditions that apply to aircraft protection for ACTIVE FROST.

** The lowest use temperature is limited to -10°C (14°F).

*** Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.

TABLE 1.6
FLUID-SPECIFIC TYPE IV HOLDOVER TIMES FOR 1998-99
CLARIANT MPIV 2001

OAT		Type IV Fluid Concentration Neat-Fluid/Water (% by volume)	Approximate Holdover Times Anticipated Under Various Weather Conditions (hours:minutes)					
°C	°F		*FROST	FREEZING FOG	SNOW	***FREEZING DRIZZLE	LIGHT FRZ RAIN	RAIN ON COLD SOAKED WING
above 0°	above 32°	100/0	18:00	2:00-3:00	1:55-2:00	0:55-1:55	0:40-1:00	0:10-0:50
		75/25	6:00	1:05-2:00	0:50-1:25	0:35-1:10	0:25-0:35	0:05-0:35
		50/50	4:00	0:20-0:45	0:10-0:20	0:10-0:20	0:10-0:15	
0 to -3	32 to 27	100/0	12:00	2:00-3:00	1:00-1:55	0:55-1:55	0:40-1:00	
		75/25	5:00	1:05-2:00	0:35-1:00	0:35-1:10	0:25-0:35	
		50/50	3:00	0:20-0:45	0:10-0:20	0:10-0:20	0:10-0:15	
below -3 to -14	below 27 to 7	100/0	12:00	0:40-3:00	0:30-0:50	**0:55-1:35	**0:30-0:45	
		75/25	5:00	0:30-2:00	0:20-0:35	**0:40-1:10	**0:20-0:30	
below -14 to -25	below 7 to -13	100/0	12:00	0:20-2:00	0:20-0:35			
below -25	below -13	100/0	SAE TYPE IV fluid may be used below -25°C (-13°F) provided the freezing point of the fluid is at least 7°C (13°F) below the OAT and the aerodynamic acceptance criteria are met. Consider use of SAE Type I when SAE Type IV fluid cannot be used.					

* During conditions that apply to aircraft protection for ACTIVE FROST.

** The lowest use temperature is limited to -10°C (14°F).

*** Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.

TABLE 1.7

FLUID-SPECIFIC TYPE IV HOLDOVER TIMES FOR 1998-99

KILFROST ABC-S

OAT		Type IV Fluid Concentration	Approximate Holdover Times Anticipated Under Various Weather Conditions (hours:minutes)					
°C	°F	Neat-Fluid/Water (% by volume)	*FROST	FREEZING FOG	SNOW	***FREEZING DRIZZLE	LIGHT FRZ RAIN	RAIN ON COLD SOAKED WING
above 0°	above 32°	100/0	18:00	2:00-3:00	1:10-2:00	1:20-1:50	1:00-1:25	0:10-0:50
		75/25	6:00	1:05-2:00	0:35-1:05	0:50-1:10	0:35-0:50	0:05-0:35
		50/50	4:00	0:20-0:45	0:05-0:20	0:15-0:20	0:10-0:15	
0 to -3	32 to 27	100/0	12:00	2:00-3:00	1:00-1:40	1:20-1:50	1:00-1:25	
		75/25	5:00	1:05-2:00	0:35-1:05	0:50-1:10	0:35-0:50	
		50/50	3:00	0:20-0:45	0:05-0:15	0:15-0:20	0:10-0:15	
below -3 to -14	below 27 to 7	100/0	12:00	0:40-3:00	0:45-1:20	**0:35-1:00	**0:20-0:40	
		75/25	5:00	0:30-2:00	0:35-1:05	**0:30-1:10	**0:25-0:35	
below -14 to -25	below 7 to -13	100/0	12:00	0:20-2:00	0:40-1:10			
below -25	below -13	100/0	SAE TYPE IV fluid may be used below -25°C (-13°F) provided the freezing point of the fluid is at least 7°C (13°F) below the OAT and the aerodynamic acceptance criteria are met. Consider use of SAE Type I when SAE Type IV fluid cannot be used.					

* During conditions that apply to aircraft protection for ACTIVE FROST.

** The lowest use temperature is limited to -10°C (14°F).

*** Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.

TABLE 1.8

FLUID-SPECIFIC TYPE IV HOLDOVER TIMES FOR 1998-99

OCTAGON MAXFLIGHT

OAT		Type IV Fluid Concentration Neat-Fluid/Water (% by volume)	Approximate Holdover Times Anticipated Under Various Weather Conditions (hours:minutes)					
°C	°F		*FROST	FREEZING FOG	SNOW	***FREEZING DRIZZLE	LIGHT FRZ RAIN	RAIN ON COLD SOAKED WING
above 0°	above 32°	100/0	18:00	2:00-3:00	1:15-2:00	0:55-2:00	0:35-1:00	0:10-0:50
		75/25	6:00	1:05-2:00	1:20-2:00	1:15-2:00	0:35-1:10	0:05-0:35
		50/50	4:00	0:20-0:45	0:40-1:20	0:35-1:00	0:15-0:30	
0 to -3	32 to 27	100/0	12:00	2:00-3:00	0:50-1:35	0:55-2:00	0:35-1:00	
		75/25	5:00	1:05-2:00	0:45-1:45	1:15-2:00	0:35-1:10	
		50/50	3:00	0:20-0:45	0:40-1:20	0:35-1:00	0:15-0:30	
below -3 to -14	below 27 to 7	100/0	12:00	0:40-3:00	0:25-0:50	**0:30-1:10	**0:20-0:40	
		75/25	5:00	0:30-2:00	0:20-0:50	**0:25-1:05	**0:20-0:30	
below -14 to -25	below 7 to -13	100/0	12:00	0:20-2:00	0:20-0:40			
below -25	below -13	100/0	SAE TYPE IV fluid may be used below -25°C (-13°F) provided the freezing point of the fluid is at least 7°C (13°F) below the OAT and the aerodynamic acceptance criteria are met. Consider use of SAE Type I when SAE Type IV fluid cannot be used.					

- * During conditions that apply to aircraft protection for ACTIVE FROST.
- ** The lowest use temperature is limited to -10°C (14°F).
- *** Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.

TABLE 1.9

FLUID-SPECIFIC TYPE IV HOLDOVER TIMES FOR 1998-99

SPCA AD-404

OAT		Type IV Fluid Concentration Neat-Fluid/Water (% by volume)	Approximate Holdover Times Anticipated Under Various Weather Conditions (hours:minutes)					
°C	°F		*FROST	FREEZING FOG	SNOW	***FREEZING DRIZZLE	LIGHT FRZ RAIN	RAIN ON COLD SOAKED WING
above 0°	above 32°	100/0	18:00	2:00-3:00	1:40-2:00	1:40-2:00	0:45-1:20	0:10-0:50
		75/25	6:00	1:05-2:00	0:50-1:45	0:50-1:50	0:30-0:50	0:05-0:35
		50/50	4:00	0:20-0:45	0:20-0:45	0:25-0:55	0:15-0:35	
0 to -3	32 to 27	100/0	12:00	2:00-3:00	1:00-1:45	1:40-2:00	0:45-1:20	
		75/25	5:00	1:05-2:00	0:25-1:00	0:50-1:50	0:30-0:50	
		50/50	3:00	0:20-0:45	0:15-0:30	0:25-0:55	0:15-0:35	
below -3 to -14	below 27 to 7	100/0	12:00	0:40-3:00	0:35-1:00	**1:05-2:00	**0:35-1:20	
		75/25	5:00	0:30-2:00	0:15-0:25	**0:30-1:45	**0:30-0:45	
below -14 to -25	below 7 to -13	100/0	12:00	0:20-2:00	0:15-0:30			
below -25	below -13	100/0	SAE TYPE IV fluid may be used below -25°C (-13°F) provided the freezing point of the fluid is at least 7°C (13°F) below the OAT and the aerodynamic acceptance criteria are met. Consider use of SAE Type I when SAE Type IV fluid cannot be used.					

* During conditions that apply to aircraft protection for ACTIVE FROST.

** The lowest use temperature is limited to -10°C (14°F).

*** Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.

TABLE 1.10

FLUID-SPECIFIC TYPE IV HOLDOVER TIMES FOR 1998-99

SPCA AD-480

OAT		Type IV Fluid Concentration Neat-Fluid/Water (% by volume)	Approximate Holdover Times Anticipated Under Various Weather Conditions (hours:minutes)					
°C	°F		*FROST	FREEZING FOG	SNOW	***FREEZING DRIZZLE	LIGHT FRZ RAIN	RAIN ON COLD SOAKED WING
above 0°	above 32°	100/0	18:00	2:00-3:00	1:10-2:00	1:05-2:00	0:50-1:10	0:10-0:50
		75/25	6:00	1:05-2:00	1:00-1:55	0:50-1:20	0:35-0:50	0:05-0:35
		50/50	4:00	0:20-0:45	0:15-0:35	0:15-0:35	0:10-0:25	
0 to -3	32 to 27	100/0	12:00	2:00-3:00	1:05-2:00	1:05-2:00	0:50-1:10	
		75/25	5:00	1:05-2:00	0:45-1:25	0:50-1:20	0:35-0:50	
		50/50	3:00	0:20-0:45	0:10-0:30	0:15-0:35	0:10-0:25	
below -3 to -14	below 27 to 7	100/0	12:00	0:40-3:00	0:20-0:40	**0:25-1:20	**0:20-0:40	
		75/25	5:00	0:30-2:00	0:15-0:25	**0:30-1:15	**0:20-0:35	
below -14 to -25	below 7 to -13	100/0	12:00	0:20-2:00	0:15-0:30			
below -25	below -13	100/0	SAE TYPE IV fluid may be used below -25°C (-13°F) provided the freezing point of the fluid is at least 7°C (13°F) below the OAT and the aerodynamic acceptance criteria are met. Consider use of SAE Type I when SAE Type IV fluid cannot be used.					

* During conditions that apply to aircraft protection for ACTIVE FROST.

** The lowest use temperature is limited to -10°C (14°F).

*** Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.

TABLE 1.11

FLUID-SPECIFIC TYPE IV HOLDOVER TIMES FOR 1998-99

UNION CARBIDE ULTRA+

OAT		Type IV Fluid Concentration Neat-Fluid/Water (% by volume)	Approximate Holdover Times Anticipated Under Various Weather Conditions (hours:minutes)					
°C	°F		*FROST	FREEZING FOG	SNOW	***FREEZING DRIZZLE	LIGHT FRZ RAIN	RAIN ON COLD SOAKED WING
above 0°	above 32°	100/0	18:00	2:00-3:00	*0:50-1:40*	*1:00-2:00*	*0:35-1:00*	*0:10-0:50*
		75/25⁽¹⁾						
		50/50⁽¹⁾						
0 to -3	32 to 27	100/0	12:00	2:00-3:00	*0:35-1:15*	*1:00-2:00*	*0:35-1:00*	
		75/25⁽¹⁾						
		50/50⁽¹⁾						
below -3 to -14	below 27 to 7	100/0	12:00	0:40-3:00	*0:25-0:55*	***0:50-1:35*	***0:30-0:50*	
		75/25⁽¹⁾						
below -14 to -25	below 7 to -13	100/0	12:00	0:20-2:00	*0:20-0:45*			
below -25	below -13	100/0	SAE TYPE IV fluid may be used below -25°C (-13°F) provided the freezing point of the fluid is at least 7°C (13°F) below the OAT and the aerodynamic acceptance criteria are met. Consider use of SAE Type I when SAE Type IV fluid cannot be used.					

* During conditions that apply to aircraft protection for ACTIVE FROST.

** The lowest use temperature is limited to -10°C (14°F).

*** Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.

[1] Diluted forms of Ultra+ are not recommended for operational use due to performance deficiencies noted in qualifying tests.

The primary effort of this year's study was directed toward the comprehensive testing of Type IV fluids representing the lowest manufacturer recommended on-wing viscosity. Extensive natural precipitation tests were conducted by APS Aviation at the Dorval Airport test site. These included snow and non-snow precipitation events. Simulated freezing drizzle, light freezing rain, freezing fog, and rain on cold-soaked surface tests were conducted at the National Research Council Canada (NRC) Climatic Engineering Facility in Ottawa.

The holdover time values in the frost columns of the various holdover time tables have been determined by the SAE G-12 Holdover Time Subcommittee, using the results of high humidity endurance time (HHET) tests conducted as part of the fluid certification process. APS has not conducted holdover time testing in simulated frost conditions.

In total, 1501 holdover time tests were conducted during the 1998-99 test season. The results of the flat plate holdover time tests were presented to the SAE G-12 Holdover Time Subcommittee where they were reviewed and discussed. New holdover time tables, based largely on this work, were proposed by the Subcommittee and accepted by the full SAE G-12 Committee. Use of these tables is to be implemented worldwide during the 1999-2000 winter season. The tables are presented in Subsection 5.6.

1.2 Objectives

The detailed objectives of the holdover time test program for the 1998-99 winter season are provided in the work statement (Appendix A). The primary objective of the test program is summarized below:

- Conduct flat plate tests under conditions of natural and simulated precipitation to record the holdover times and to develop individual holdover time tables based on samples of new and previously qualified anti-icing fluids at their lowest acceptable on-wing viscosity.

1.3 Report Format

The following list provides short descriptions of the remaining sections of the report:

- Section 2 describes the test conditions and methodologies used as well as equipment and personnel requirements necessary to carry out testing;

- Section 3 describes the different conditions under which data were collected;
- Section 4 presents the results of fluid thickness tests conducted in periods of no precipitation and the results of these tests;
- Section 5 contains discussions related to the data and results of holdover time testing. The most recently generated, proposed, and accepted SAE and fluid-specific holdover time tables destined for use during the 1999-2000 winter season are also presented;
- Section 6 presents the results and general information related to supplementary tests performed during the winter 1998-99 test season;
- Section 7 presents conclusions derived from the complete test program; and
- Section 8 lists recommendations for future testing.

2. METHODOLOGY

This chapter contains a description of the tests, equipment, and procedures used during the 1998-99 test season. It is divided into sections dealing with the definition of weather, test sites, test conditions, equipment, procedures, data forms, fluids, personnel, and analysis methodology.

2.1 Definition of Weather Conditions

Holdover times (see Tables 1.2 to 1.11) are provided as a function of weather condition, fluid mixture and outside air temperature. The objective of the winter test program was to substantiate these holdover times or develop new ones based on the most recent test data.

Table 2.1 provides definitions of most weather conditions experienced in winter operations and includes the criteria used to determine precipitation intensity (light, moderate, heavy). This table was compiled by the National Center for Atmospheric Research (NCAR) from the *World Meteorological Organization Guide to Meteorological Instruments and Methods of Observation* (2), and from the *American Meteorological Society, Glossary of Meteorology WSOH # 7 Manual of Surface Weather Observations (MANOBS)* (3).

Table 2.1 includes definitions for the weather conditions described in the holdover time tables presented in Section 1.1 (frost, freezing fog, snow, freezing drizzle, light freezing rain and rain). Definitions for snow pellets, snow grains, hail and ice pellets are also presented; however, these are conditions for which holdover time guidelines do not exist.

The test methodology used to determine fluid failure times has included the generally accepted upper and lower limits for precipitation rates for each type of precipitation. These limits were discussed in detail at a 1997 meeting of the SAE G-12 Holdover Time Subcommittee where standard definitions of upper and lower precipitation rate limits were approved for each category of precipitation. These limits are documented and discussed in Subsection 2.9.

2.1.1 Snow

Table 2.1 contains the criteria historically used to estimate the intensity of snow. These criteria are based on horizontal visibility. Three intensity levels are defined as follows:

• Light	Visibility is ≥ 1.0 km
• Moderate	Visibility is 0.5 km to < 1.0 km
• Heavy	Visibility is < 0.5 km

TABLE 2.1

DEFINITION OF WEATHER PHENOMENA

Weather Phenomenon*	Definition*
FROST (No METAR code) Note: No Intensity is assigned to FROST.	Ice crystals that form from ice-saturated air at temperatures below 0°C (32°F) by direct sublimation on the ground or other exposed objects.
FREEZING FOG (FZFG) Note: No Intensity is assigned to FRZ FOG.	A suspension of numerous minute water droplets which freezes upon impact with ground or other exposed objects, generally reducing the horizontal visibility at the earth's surface to less than 1 km (5/8 mile).
SNOW (SN)	Precipitation of ice crystals, most of which are branched, star-shaped, or mixed with unbranched crystals. At temperatures higher than about -5°C (23°F), the crystals are generally agglomerated into snowflakes.
FRZING DRIZZLE (FZDZ)	Fairly uniform precipitation composed exclusively of fine drops [diameter less than 0.5 mm (0.02 in.)] very close together which freezes upon impact with the ground or other exposed objects.
FREEZING RAIN (FZRA)	Precipitation of liquid water particles which freezes upon impact with the ground or other exposed objects, either in the form of drops of more than 0.5 mm (0.02 in.) or smaller drops which, in contrast to drizzle, are widely separated.
RAIN (RA)	Precipitation of liquid water particles either in the form of drops of more than 0.5 mm (0.02 in.) diameter or of smaller widely scattered drops.
SNOW PELLETS (GS)	Precipitation of white and opaque grains of ice. These grains are spherical or sometimes conical; their diameter is about 2-5 mm (0.1-0.2 in.). Grains are brittle, easily crushed; they bounce and break on hard ground.
SNOW GRAINS (SG)	Precipitation of very small white and opaque grains of ice. These grains are fairly flat or elongated; their diameter is less than 1 mm (0.04 in.). When the grains hit hard ground, they do not bounce or shatter.
HAIL (GR)	Precipitation of small balls or pieces of ice with a diameter ranging from 5 to > 50 mm (0.2 to 2.0 in.) falling either separately or agglomerated.
ICE PELLETS (PE) Note: Includes Sleet and Small Hail	Precipitation of transparent (sleet or grains of ice), or translucent (small hail) pellets of ice, which are spherical or irregular, and which have a diameter of 5 mm (0.2 in.) or less. The pellets of ice usually bounce when hitting hard ground.

Intensity Criteria**

	Snow(SN),Pellets(GS),Grains(SG),Frz Drizzle(FZDZ)		Ice Pellets (PE)
Estimated Intensity	**Horizontal Visibility (statute mile)**	**Liquid Equivalent Snow (S) Intensity*** **	**Definition and Horizontal Visibility**
Light (-)	If visibility is: ≥ 5/8 mi (≥ 1.0 km)	Trace to 0.05 in/hr (≤ 1.0 mm or 10.0 gr/dm²/hr)	Scattered pellets on the ground. Visibility not affected.
Moderate	If visibility is: < 5/8 to 5/16 mi (< 1.0 to 0.5 km)	> 0.05 to 0.10 in/hr (> 1.0 to 2.5 mm/hr) (> 10.0 to 25.0 gr/dm²/hr)	Slow accumulation on the ground. Visibility reduced to less than 7 mi.
Heavy (+)	If visibility is: < 5/16 mi (< 0.5 km)	More than 0.10 in/hr (> 2.5 mm or 25.0 gr/dm²/hr)	Rapid accumulation on the ground. Visibility reduced to less than 3 mi.

Note: Horizontal visibility is only an estimation of snow and freezing drizzle intensity. Measurements and observations have shown that visibility and precipitation intensity are not always directly correlated.

	Drizzle Intensity (FZDZ)
Light(-)	Trace to 0.01 in/hr (0.254 mm or 2.54 gr/dm²/hr)
Moderate	From 0.01 to 0.02 in/hr (2.54 to 5.08 gr/dm²/hr)
Heavy(+)	More than 0.02 in/hr (> 5.08 gr/dm²/hr) Note: Drizzle > 0.04 in/hr is usually in the form of rain.

		Rain (RA), Freezing Rain (FZRA), Ice Pellets (PE)
Light (-)	Measured Intensity	Up to 0.10 in/hr (2.5 mm or 25 gr/dm²/hr); Maximum 0.01 inch in 6 minutes
	Estimated Intensity	From scattered drops that, regardless of duration, do not completely wet an exposed surface up to a condition where individual drops are easily seen.
Moderate	Measured Intensity	0.11 in to 0.30 in/hr (7.6 mm or 76 gr/dm²/hr); More than 0.01 to 0.03 inch in 6 minutes
	Estimated Intensity	Individual drops are not clearly identifiable; spray is observable just above pavement and other hard surfaces.
Heavy (+)	Measured Intensity	More than 0.30 in/hr (7.6 mm or 76 gr/dm²/hr); More than 0.03 inch in 6 minutes
	Estimated Intensity	Rain seemingly falls in sheets; individual drops are not identifiable; heavy spray to height of several inches is observed over hard surfaces.

1) gr/dm² = 0.01 cm = 0.1 mm = 0.0039 in
2) in = 2.54 cm = 25.4 mm = 254 gr/dm²

Compiled by Jeff Cole and Roy Rasmussen of NCAR/RAP June 17, 1997
(Updated for METAR codes)

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* From World Meteorological Organization Guide to Meteorological Instruments and Methods of Observation (1983)
** From American Meteorological Society, Glossary of Meteorology WSOH #7 MANOBS (3/94)
*** NCAR Proposed Definition for Liquid Equivalent Snowfall Intensity

Visibility, however, is only an indicator of snow intensity, and the two parameters are not always correlated as is indicated in a cautionary note in Table 2.1.

Table 2.2 was devised by NCAR and Transport Canada. This table is based on NCAR field data and theoretical work on classes of snow. NCAR has classified the snow data by crystal arrangement and temperature and has correlated this information with visibility measurements. The table is a more detailed scheme than the one outlined in Table 2.1. It gives visibility in distance for three snowfall intensities both in daylight and in darkness (night). The Snow Visibility versus Snowfall Intensity Chart, shown in Table 2.2, has been included in a Transport Canada Aviation Circular for 1999-2000.

2.1.2 Freezing Drizzle

Freezing drizzle is composed of closely spaced fine water droplets with a diameter less than 0.5 mm (see Table 2.1). The intensity of freezing drizzle is estimated, as for snow, through the measurement of horizontal visibility. The holdover time table has one column for freezing drizzle, but Table 2.1 shows three intensity levels (light, moderate and heavy). For example, under moderate freezing drizzle, the rate of precipitation should range between 2.5 and 5.1 g/dm²/h. For heavy freezing drizzle, the definition indicates that the intensity is greater than 5 g/dm²/h. Discussions between United Airlines, NCAR and NRC led to the upper limit value of 12.7 g/dm²/h for freezing drizzle. This value was also used as the lower limit for light freezing rain.

2.1.3 Freezing Rain

This form of precipitation exists either in the form of drops with diameters greater than 0.5 mm, or smaller drops which, in contrast to drizzle, are widely separated. For each of the three intensities of freezing rain given in Table 2.1, a visual description is supplied to provide a subjective guideline for the purpose of estimating rain intensity. However, the following definitions apply when an instrument is available to measure the intensity of precipitation:

• Light	Precipitation rate is ≤25 g/dm²/h
• Moderate	Precipitation rate is >25 g/dm²/h but ≤76 g/dm²/h
• Heavy	Precipitation rate is >76 g/dm²/h

TABLE 2.2

SNOW VISIBILITY vs SNOWFALL INTENSITY CHART

Lighting	Temperature Range		Visibility in Statue Miles		
	°C	°F	Heavy*	Moderate*	Light*
Daylight	Above -1	Above 30	<1	1 - 2	>2
	-1 to -7	30 to 19	<1/2	1/2 - 1 1/4	>1 1/4
	Below -7	Below 19	<3/8	3/8 - 5/8	>5/8
Darkness	Above -1	Above 30	<2	2 - 4	>4
	-1 to -7	30 to 19	<1	1 - 2 1/2	>2 1/2
	Below -7	Below 19	<3/4	3/4 - 1 1/4	>1 1/4

* Light snow intensity is defined as less than 1 mm/hr equivalent liquid water, moderate intensity as 1 mm/hr to 2.5 mm/hr equivalent liquid water, and heavy as greater than 2.5 mm/hr equivalent liquid water.

Transport Canada, August 1999

2.1.4 Freezing Fog

Freezing Fog is defined as suspended minute water droplets that freeze upon impact with the ground or exposed objects. Table 2.1 does not provide any indication of intensity or liquid water content of the fog other than that the horizontal visibility is reduced to less than 1 km.

2.2 Test Sites

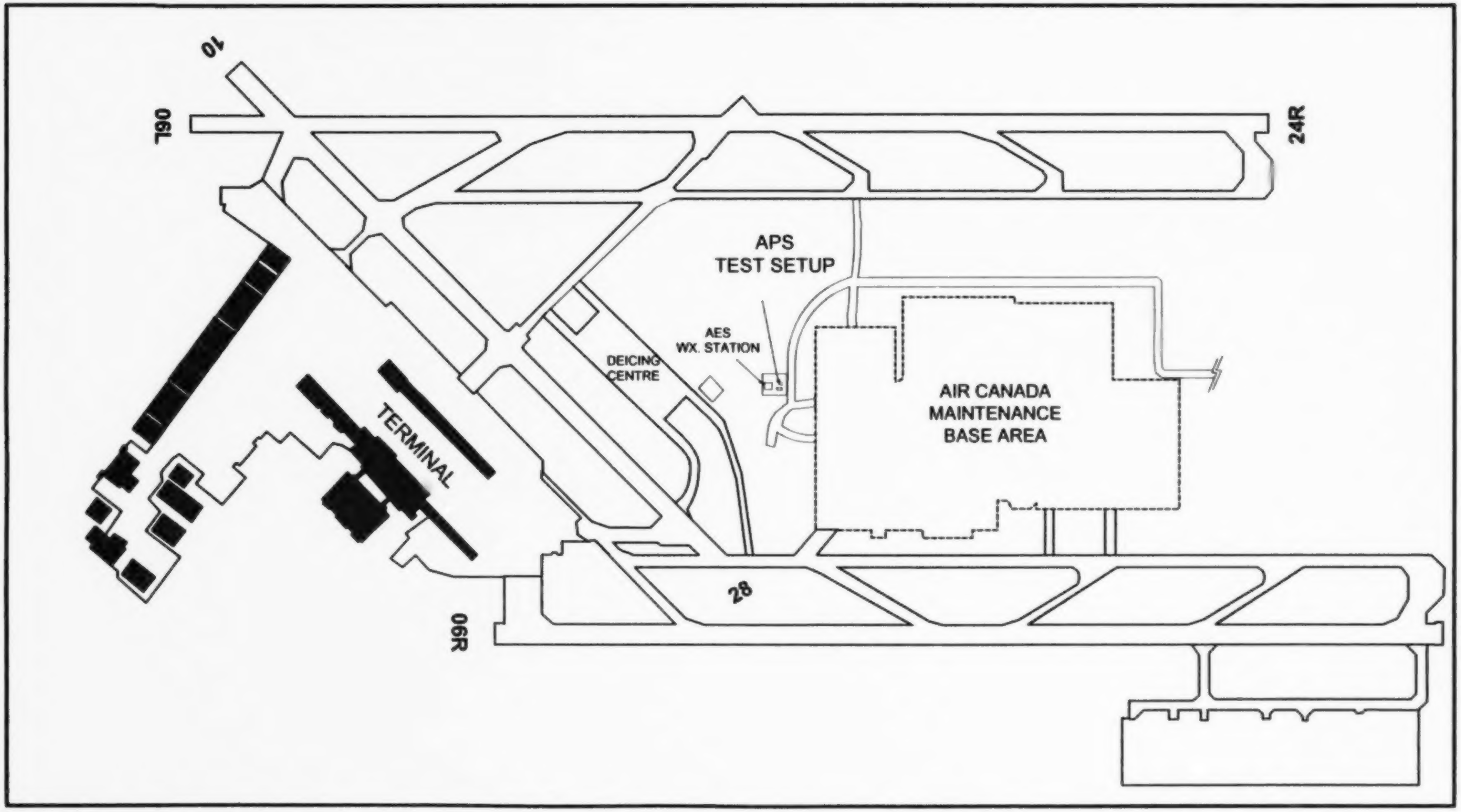
Natural snow testing for the 1998-99 winter was performed at the APS Dorval Airport test site. The location of the site is shown on the plan view of the airport in shown Figure 2.1. Photo 2.1 was taken at the site and shows a remote sensor mounted on top of the test stand on the left and the trailer at the back. The trailer used in past winters was kept in place for the 1998-99 winter. The test site is located adjacent to Environment Canada's Atmospheric Environment Services automated weather observation station (Photo 2.2).

Tests under conditions of freezing fog, rain on cold-soaked surface, freezing drizzle, and light freezing rain were conducted indoors at NRC's indoor Climatic Engineering Facility (CEF), where precipitation was artificially produced. Tests in simulated snow were also conducted at the CEF using the NCAR artificial snow generation system.

The CEF is partitioned into two sections, separated by an insulated dividing door. Each partition can be separately controlled, permitting different tests to be conducted simultaneously. Photo 2.3 provides a general indication of the size of the facility. Photos 2.4 and 2.5 provide interior images of the small and large ends of the facility. The facility was designed and built for the testing of locomotives. The size of the chamber is 30 m by 5.4 m and its total height is 8 m. The lowest temperature achievable is -46°C.

FIGURE 2.1

DEICING PAD LOCATION AT DORVAL AIRPORT


10
06L
24R
APS
TEST SETUP
AES
WX. STATION
DEICING
CENTRE
TERMINAL
AIR CANADA
MAINTENANCE
BASE AREA
28
06R
24L

cm1380\presenta\ottawa\DEIC_PAD.DRW

2.3 Test Conditions

Outdoor testing was conducted during natural precipitation events. Supplementary tests to simulate freezing precipitation were carried out at NRC's CEF (see Photo 2.4). Subsections 2.3.1 and 2.3.2 provide descriptions of the spray assembly (see Photo 2.6) and of the methods used to produce and calibrate the fine water droplets in these artificial precipitation tests. Subsection 2.3.3 provides a summary of the categories and characteristics of each precipitation type produced for these tests.

2.3.1 Droplet Size and Rate of Precipitation

Over the most recent years of holdover time tests, more industry attention has been given to the influence of droplet size on holdover time. To clarify this issue, experiments were performed to measure droplet sizes produced by different nozzles (various gauge hypodermic needle tips) and different water and air pressures used in the spray delivery unit. Although the gauge of the needles is an important factor in the production of water droplets with appropriate dimensions, the air and water pressure levels in the sprayer system are as important. A new and improved sprayer assembly was developed in 1997-98 by NRC and is shown in Photo 2.6. The new sprayer provides a larger scan area and improved spray uniformity over the test bed area.

The scanner consists of a horizontal main shaft, supported by two bearings. The actual spray head assembly is shaft-mounted on a rotating scanner, such that one scan covers a lateral running strip of the test bed area. A stepper motor is synchronized to index the relative angle of the spray head between scans along an axis perpendicular to the scan axis. This amounts to having two axes of rotation, essentially an x-y plane; one along each axis. Each scan is consecutively indexed in order to complete the precipitation coverage of the test bed area. This defines one cycle of the spray unit. The scan rate, index angle and the number of scans per cycle are adjusted, along with the fluid delivery pressures (water and air) to obtain appropriate droplet sizes and precipitation rates. The spray nozzle is shown in Photo 2.7.

Early calibration experiments were conducted prior to 1995 by NRC using an optical gauge manufactured by HSS (see Photo 2.8) to verify that the simulation of freezing fog, freezing drizzle and light freezing rain provided adequate droplet sizes.

After 1995, droplet size calibration was carried out by the APS team using a manual dye-stain technique (4) employed by NRC's CEF. This technique consists of dusting Whatman # 1 filter paper discs with a water-activated, very finely divided powder form of methylene blue dye. The prepared discs are manually positioned (Photo 2.9) under artificial precipitation for a fixed time in order to acquire a droplet size pattern. Figure 2.2 illustrates the appearance of such a pattern acquired under conditions of light freezing rain. A calibration curve is then used to convert from the measured diameter of the droplets on the pattern to the experimental median volume diameter.

To determine whether droplets produced in the cold chamber resembled droplets from natural precipitation, a test was conducted during natural light freezing rain conditions in 1997-98. The droplet sizes were measured and compared to the droplet sizes of simulated light freezing rain tests conducted at NRC. The results of these tests are shown below:

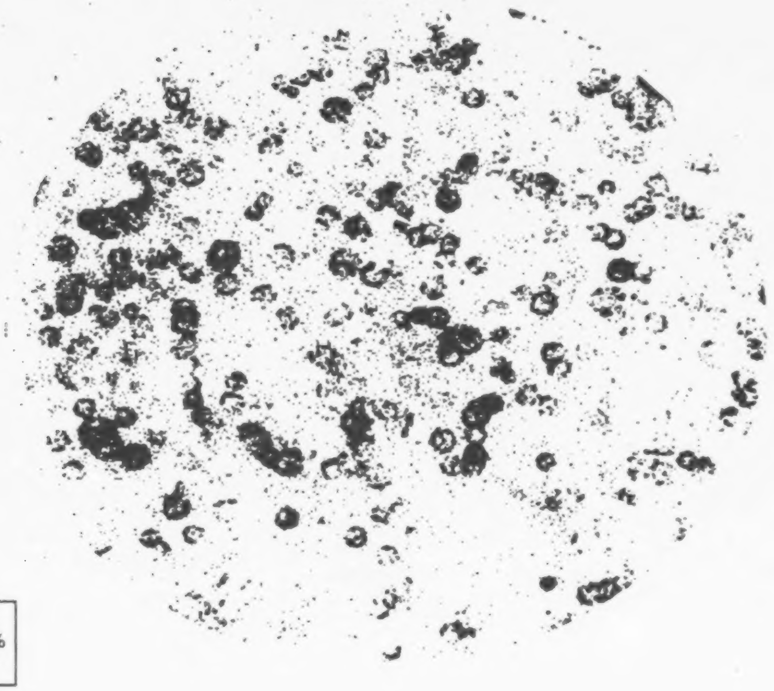
For the outdoor test:
Location: Dorval Airport
Precipitation: Natural Light Freezing Rain
Precipitation Rate: 20 $g/dm^2/h$
Calibrated MVD: 1.0 mm

For the indoor test:
Location: NRC
Precipitation: Simulated Light Freezing Rain
Precipitation Rate: 25 $g/dm^2/h$
Calibrated MVD: 1.0 mm

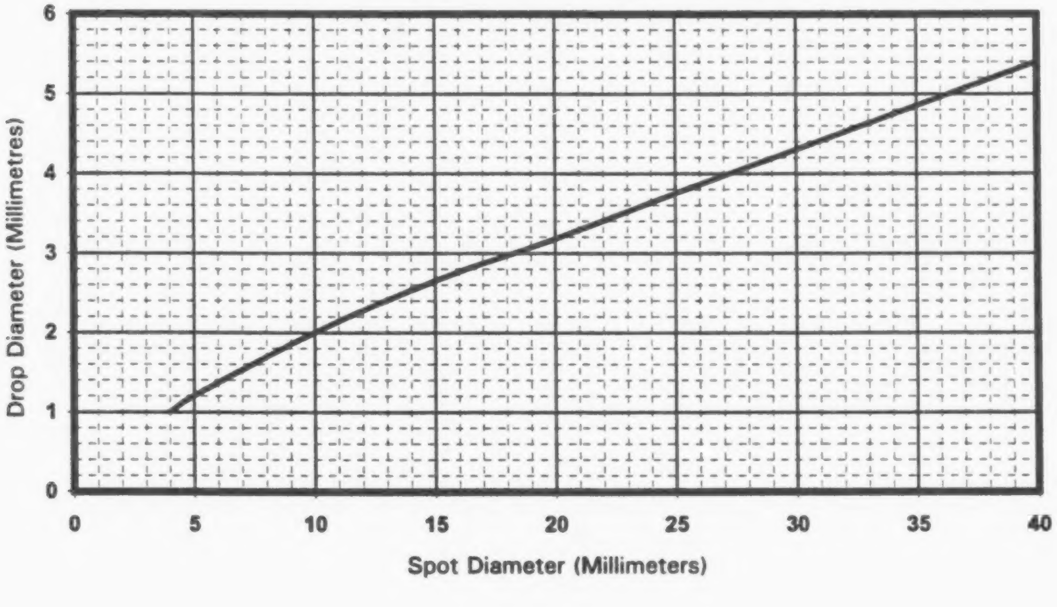
The median volume diameter for both natural and simulated light freezing rain was 1 mm.

During the past year, droplet size calibration was conducted by APS staff using both the dye stain and slide impact methods. The slide impact method consists of spreading mineral or silicone oil with a known viscosity (5000 mPas) onto a microscope slide, and placing the slide under precipitation to collect water droplets within the oil on the slide. The droplet size is then determined by direct observation under a microscope equipped with a ruled graticule eyepiece or from enlarged photographs of the slide.

FIGURE 2.2
DROPLET SIZE PATTERN PRODUCED AT NRC
LIGHT FREEZING RAIN



This figure was reduced by about 33% to fit this page.



CONVERSION OF SPOT DIAMETER TO DROP DIAMETER

WHATMAN # 1 FILTER PAPER

2.3.2 Median Volume Diameter of Rain Drops

The median volume diameter (MVD) of a rain droplet has been researched and found to be related to the precipitation rate as follows (4):

$$\text{MVD} = (\text{rate}/10)^{0.23} \qquad (1)$$

where the MVD is in mm and the rate of precipitation is in g/dm²/h. At 25 g/dm²/h, this equation gives an MVD of 1.2 mm, and at 76 g/dm²/h the MVD is 1.6 mm.

The theoretical MVDs for rain at various rates of precipitation were determined based on this equation. These values are listed in Table 2.3 beside the experimental MVDs for each precipitation condition.

Table 2.3 Median Volume Diameters

	Experimental **MVD (mm)**	Theoretical **MVD (mm)**
Moderate Rain (High rate: 76 g/dm²/h)	1.4	1.6
Light Rain (Low rate: 12.7 g/dm²/h	1.0	< 1.1
Light Rain (High rate: 25 g/dm²/h)	1.0	1.2
Drizzle (Low rate: 5 g/dm²/h)	0.25	< 0.5
Drizzle (High rate: 12.7 g/dm²/h)	0.35	< 0.5
Fog		< 0.1

2.3.3 Characteristics of Precipitation Produced

The following is a point-form summary of the set of test conditions under which data for freezing drizzle, light freezing rain, rain on a cold-soaked surface, and freezing fog were collected:

1) Freezing Drizzle:

High precipitation rate: 12.7 g/dm²/h;
Droplet median volume diameter: 350 µm;
Droplets produced with two # 23 hypodermic needles; and
Air temperature: -3 and -10°C.

Low Precipitation rate: 5 g/dm²/h;
Droplet median volume diameter: 250 µm;
Droplets produced with two # 24 hypodermic needles; and
Air temperature: -3 and -10°C.

2) Light Freezing Rain:

High precipitation rate: 25 g/dm²/h;
Droplet median volume diameter: 1 000 μm;
Droplets produced with two # 20 hypodermic needles; and
Air temperature: -3 and -10°C.

Low precipitation rate: 12.7 g/dm²/h;
Droplet median volume diameter: 1 000 μm;
Droplets produced with two # 20 hypodermic needles; and
Air temperature: -3 and -10°C.

3) Drizzle on Cold-Soaked Surface:

Precipitation rate: 5 g/dm²/h;
Droplet median volume diameter: 250 μm;
Droplets produced with two # 24 hypodermic needles; and
Air temperature: +1°C.

4) Moderate Rain on Cold-Soaked Surface:

Precipitation rate: 76 g/dm²/h;
Droplet median volume diameter: 1 400 μm;
Droplets produced with two # 17 hypodermic needles; and
Air temperature: +1°C.

5) Freezing Fog:

Precipitation rate: 2 and 5 g/dm²/h;
Droplet median volume diameter: 30 μm; and
Air temperature: -3°C, -14°C and -25°C.

2.4 Equipment

Figure 2.3 shows a schematic of the test platform used in holdover time testing. For natural snow tests, six test plates are normally mounted on the test stand, which has a working surface inclined at 10° to the horizontal. Each plate represents a flat plate test.

Figure 2.3 also depicts the size and surface markings of a standard flat plate. Three parallel lines are positioned at 2.5 cm (1 in.), 15 cm (6 in.) and 30 cm (12 in.) from the top of the plate. The plates were marked with 15 crosshairs used in determining whether end conditions (see Subsection 2.5.2 for definition) were achieved. Photo 2.10, taken outdoors at Dorval, shows six test plates mounted on a stand; two plates (u and w) are equipped with AlliedSignal Contaminant/Fluid Integrity Monitoring System (C/FIMS) ice detection sensors mounted at the 15 cm line. For simulated freezing precipitation tests at NRC, 12 plates were mounted on the stand, marked 1 to 12, as shown in Figure 2.3.

Figure 2.4 shows the collection (plate) pan, which is the same size as a standard flat plate and is used to make precipitation rate measurements during outdoor tests. Photo 2.11 shows the collection pans used for measuring precipitation rates indoors at NRC.

A new snow gauge, CR21X, was made available to measure precipitation during the 1996-97 winter season. The unit gave inaccurate results because it had not been properly shielded. During the past two years, the instrument has been shielded and has since provided improved accuracy and resolution over instrumentation used in previous seasons. A detailed analysis of the results obtained in 1997-98 from the CR21X snow gauge is presented in Transport Canada report TP 13314E (5). Further analysis of CR21X results is presented in an associated report, TP 13486E (6).

Sealed boxes (7.5 cm deep) were used for simulating a cold-soaked wing (see Figure 2.4). The top of the cold-soak box consists of an aluminum flat plate identical to the standard flat plate. A box-shaped reservoir is welded to the bottom of the plate. The volume (depth) of the reservoir was selected based upon the analyses contained in related Transport Canada report, TP 12899E (7).

The fluid cooling unit, devised and constructed by APS personnel, uses liquid nitrogen as a refrigerant and is shown in Photo 2.12. The unit was designed to rapidly cool the glycol used to fill the cold-soak boxes. A mixer was added to the unit to stir the glycol inside the cooling unit. This improved the efficiency of the cooling process and assured fluid temperature homogeneity.

FIGURE 2.3

FLAT PLATE TEST SET-UP

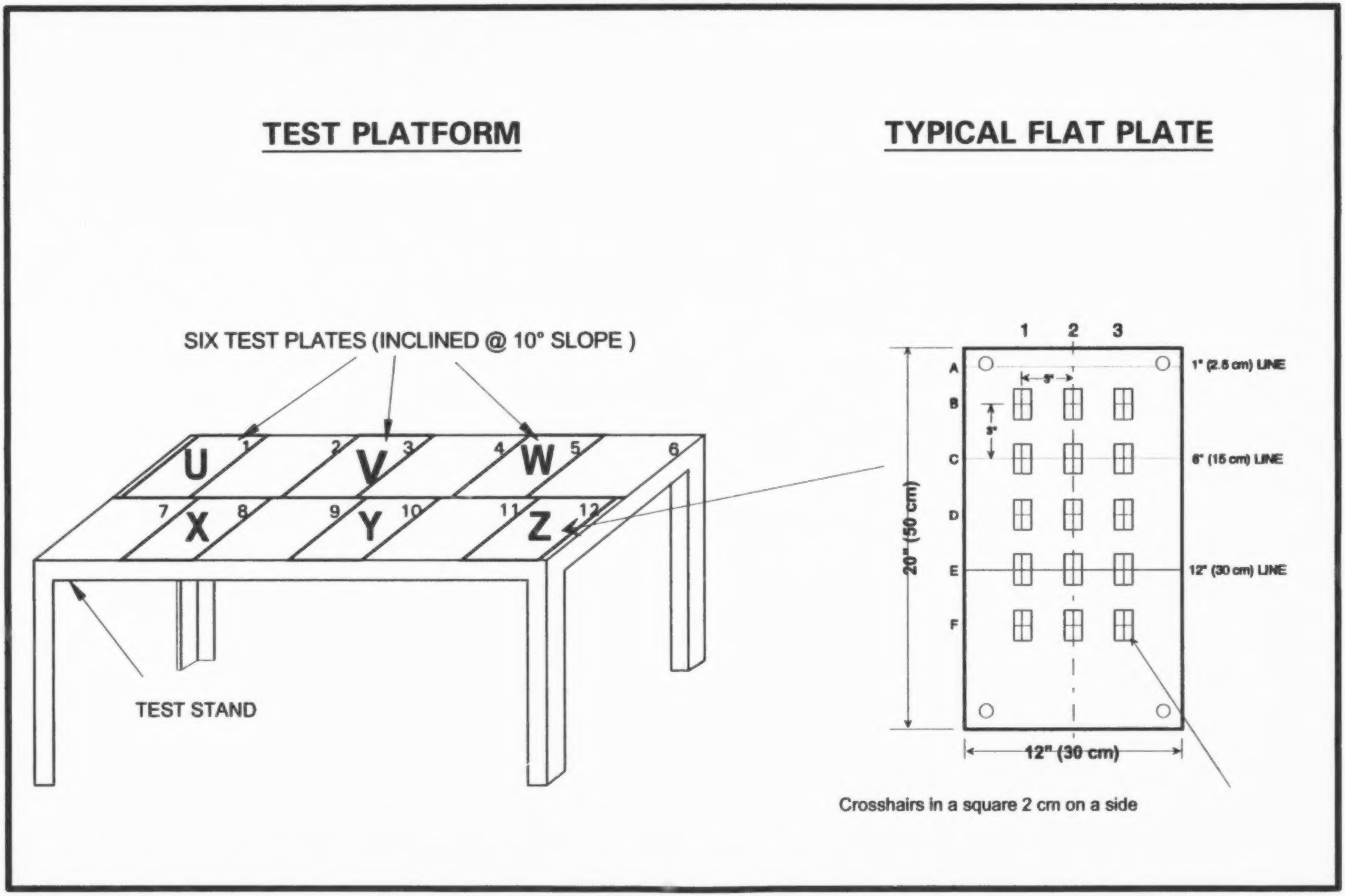
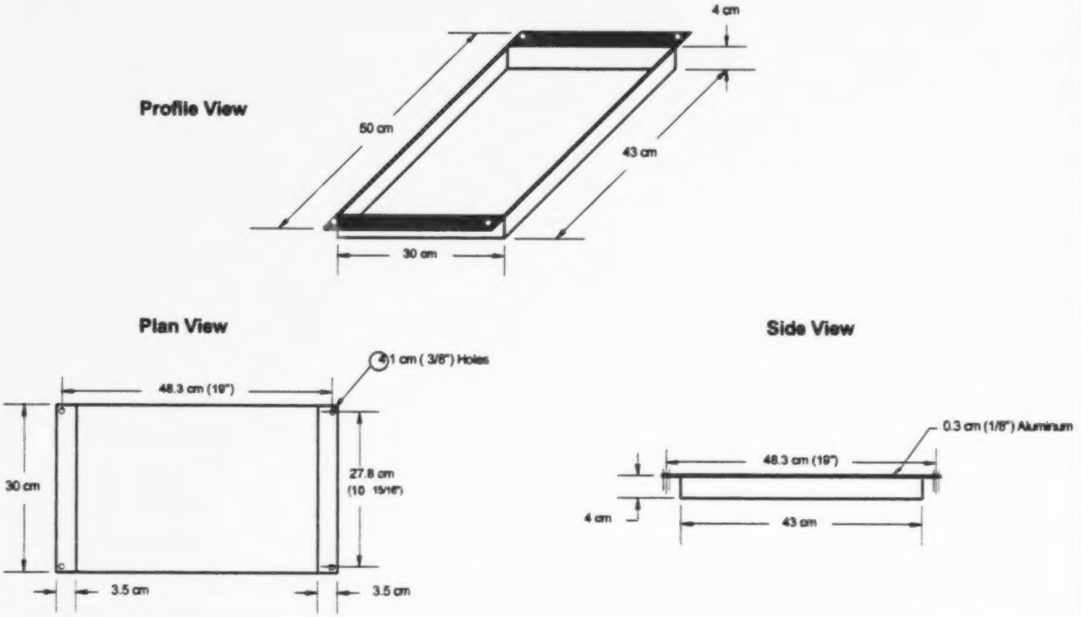

TEST PLATFORM
SIX TEST PLATES (INCLINED @ 10° SLOPE)
U
V
W
X
Y
Z
1
2
3
4
5
6
7
8
9
10
11
12
TEST STAND
TYPICAL FLAT PLATE
1
2
3
A
B
C
D
E
F
3"
3"
1" (2.5 cm) LINE
6" (15 cm) LINE
12" (30 cm) LINE
20" (50 cm)
12" (30 cm)
Crosshairs in a square 2 cm on a side

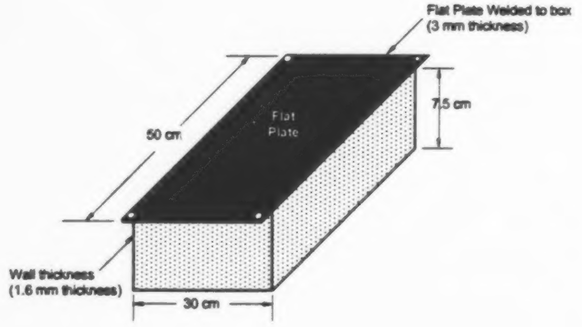
FIGURE 2.4

SCHEMATICS OF PLATE PAN AND SEALED BOXES

PLATE PAN USED OUTDOORS


Profile View
4 cm
50 cm
43 cm
30 cm
Plan View
4 1 cm (3/8") Holes
48.3 cm (19")
30 cm
27.8 cm
(10 15/16")
3.5 cm
3.5 cm
Side View
0.3 cm (1/8") Aluminum
48.3 cm (19")
4 cm
43 cm

SEALED BOXES FOR COLD-SOAK SIMULATION

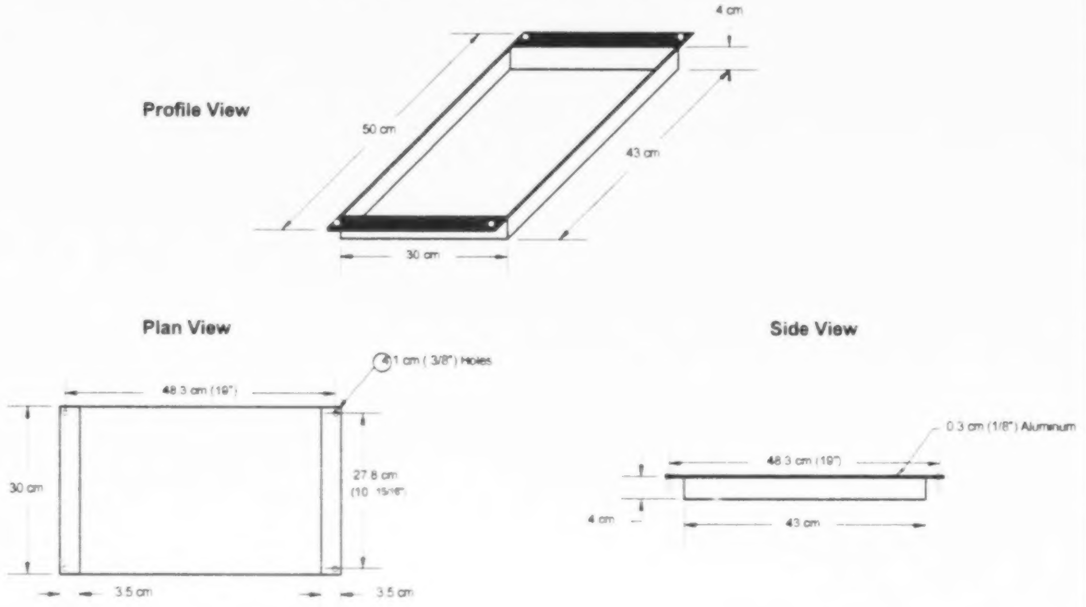

Flat Plate Welded to box
(3 mm thickness)
7.5 cm
50 cm
Flat
Plate
Wall thickness
(1.6 mm thickness)
30 cm

cm1514\report\hot_subs\pan&box.drw

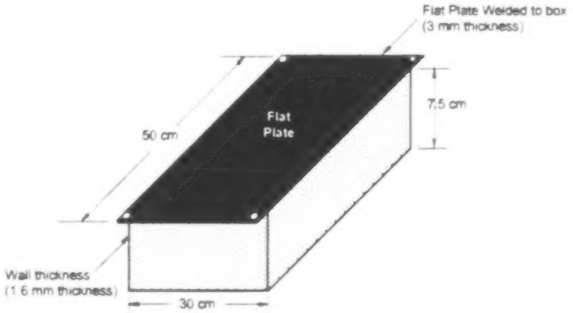
FIGURE 2.4

SCHEMATICS OF PLATE PAN AND SEALED BOXES

PLATE PAN USED OUTDOORS


4 cm
Profile View
50 cm
43 cm
30 cm
Plan View
Side View
1 cm (3/8") Holes
48.3 cm (19")
30 cm
27.8 cm
(10 15/16")
3.5 cm
3.5 cm
0.3 cm (1/8") Aluminum
48.3 cm (19")
4 cm
43 cm

SEALED BOXES FOR COLD-SOAK SIMULATION


Flat Plate Welded to box
(3 mm thickness)
7.5 cm
50 cm
Flat
Plate
Wall thickness
(1.6 mm thickness)
30 cm

cm1514\report\fnl auto\pan&box.drw

A new fluid cooling unit, the Neslab Model HX 300, was used during the past test season (see Photo 2.13). A constant temperature bath, the unit has a temperature range of -15°C to 30°C and is rated to provide a maximum recirculation rate of 10 gpm. A closed loop is created between the unit and the cold-soak box, allowing fluid to flow continuously between the two. When the fluid in the cold-soak box reaches the desired temperature, the inlet and outlet valves of the cold-soak box are shut.

Two large digital clocks, which are visible from a great distance, were purchased in 1998-99 to facilitate the recording of precipitation rate collection times in natural and simulated conditions (see Photo 2.14).

Fluid freeze points were measured using a hand-held Misco refractometer with a Brix scale (see Photo 2.15).

Equipment to measure temperature, wind speed and wind direction was purchased several years ago (see Photo 2.1). Additional measurement of these parameters is provided by Environment Canada's equipment seen in Photo 2.2.

Ice sensors used during natural snow outdoor tests, and at NRC's CEF in the 1998-99 season, included four C/FIMS from AlliedSignal and one optical sensor by Spar/Cox, shown in Photo 2.16. The Spar/Cox sensor was made available only at the end of the 1998-99 winter season, but was used for testing at NRC.

In addition to the data collected using the meteorological equipment at the APS Dorval site, data from Environment Canada's automated weather observation equipment, located on a lot adjacent to the test site, were made available by the Remote Environmental Automatic Data Acquisition Concept (READAC). This information was acquired from Atmospheric Environment Services magnetically on a minute-by-minute basis for the entire winter. The READAC equipment provides an indispensable means of monitoring meteorological conditions for test programs such as this. It consists of the following instruments:

1) *Relative Humidity Gauge and Thermometer.*

2) *Anemometer and wind vane at a 10 m height.*

3) *Precipitation Occurrence Sensing System (POSS):* The POSS system (Instrument at rear of Photo 2.17) consists mainly of a Doppler radar set with a transmitter and a receiver as separate units (bi-static set-up).

The system is aimed at an area a few centimetres above the system, where it measures the rate of fall of hydrometers. The Doppler frequency shift of the returned signal provides the precipitation type, and the power spectrum of the returned signal provides a measure of the intensity (light, moderate or heavy) of precipitation. The output of the system consists of the start time, stop time, type, and intensity of precipitation.

4) *Precipitation Gauge:* The READAC precipitation gauge (instrument at right of Photo 2.17) is a modified Belfort weighing gauge. A bucket is attached to a spring balance and cable pulley arrangement connected to a rotating shaft. The degree of rotation of the shaft corresponds to the amount of accumulated precipitation in the bucket. The total amount of precipitation is the only value returned by the precipitation gauge arrangement. The gauge output resolution is 0.5 mm (liquid water equivalent).

5) *Belfort Forward Scattermeter:* The Belfort Forward Scattermeter (instrument at left of Photo 2.17) provides an estimate of visibility. The system consists of a Zenon bulb transmitter and a receiver both at an angle of 22° below the horizontal aimed at a 0.02 m^3 sample volume of air 2.5 m above the ground. The transmitter illuminates the sample volume of air. The receiver measures the amount of light scattering off the aerosols present in the sample volume of air. The measurement is inversely proportional to visibility. The instrument output scale is in units of miles. The measurements outputted by the instrument at any time are the time averaged signal envelopes from the previous ten minutes of monitoring.

2.5 Test Procedures

Tests consisted of pouring deicing or anti-icing fluids directly onto clean test panels (exposed to various winter precipitation conditions) and recording the elapsed time for each crosshair to fail until the test panels reached the defined end condition (see Subsection 2.5.2).

2.5.1 Test Protocol

For the tests at Dorval, a test stand contained six test plates, each plate representing a flat plate test. During each run with six plates, three different fluids were tested in duplicate.

The procedure for natural snow flat plate tests was developed by the SAE G-12 Holdover Time Subcommittee. The major changes this year were:

1) Two clocks, one positioned above the rate station, the other positioned in a trailer window facing the test area, were used to determine the precise time (in hr:min:sec) of the rate collection period; and
2) Fluid freeze point measurements were not collected following plate failure.

The major steps in the natural snow flat plate test procedure are:

1) Synchronize all timepieces;
2) Clean panels and start timepieces;
3) Apply (pour) fluids to test panels. Type I fluids are at room temperature (20°C ± 3°C). Type II and Type IV fluids are applied at the outdoor ambient temperature. Fluids are poured using a single-step fluid application;
4) Record crosshair end condition times;
5) Continue testing until at least five crosshairs or 1/3 of the plate have failed;
6) Record weather conditions; and
7) Clean panels and restart.

Complete details of the actual test procedures are provided in Appendix B.

Appendix C contains the procedures used for testing at the Climatic Engineering Facility in freezing drizzle, light freezing rain and freezing fog, and for rain on a cold-soaked surface.

2.5.2 End Condition Definitions

The test procedures and the determination of defined end conditions evolved from the experience the APS test team has accumulated from previous winter season test programs. Any of the following descriptions provide the general guidelines that observers use to judge when fluid failure occurs and to judge the extent of contamination or failure:

- There is a visible accumulation of snow bridging on top of the fluid or plate when viewed from the front. There should be an indication that the fluid can no longer absorb the precipitation at this point; or
- Ice has formed or accumulated on top of the plate or fluid, or when ice is suspended within the fluid (freezing precipitation tests); or
- When precipitation produces a *loss of gloss* (i.e. dulling of the surface reflectivity).

The standard flat plate end condition is achieved when failures occur either at any 5 of the crosshair markings on the plate, or when the general failure coverage reaches 1/3 of the entire test plate surface.

2.5.3 Precipitation Rate Procedures

2.5.3.1 Simulated Precipitation Conditions

Prior to the start of the rate collection period, the proper needles and nozzles are installed in the spray unit, and both the air and water pressures are adjusted. Water spray calibration is performed by placing catch pans on the test stand, each pan marked with a number identifying the collection location on the test stand, and exposing the pans to a predetermined precipitation collection period.

The pans are weighed prior to exposure to precipitation and the weights are recorded. Prior to the start of the precipitation catch period, the exact time (hh:mm:ss) is recorded. The pans are re-weighed following this collection period and the precipitation rates over the area of the test stand are examined. If the rates are unacceptable, re-calibration of the water spray is necessary. If the rates are deemed to be acceptable, the pans are weighed and placed on the stand for a second collection period. After the second collection period has expired, the pans are again re-weighed and the rates computed.

Once two rates have been collected at each test location, the catch rates of the first and second collection are compared. If the average catch rate for any location is deemed to be acceptable for this condition, then the pouring of fluids may begin at this location.

Rates are continuously monitored at a minimum of two locations during a test in order to ensure there are no significant rate fluctuations. Pans will be placed at these locations and re-weighed at fixed intervals (15 minutes, typically) during the course of a test. If a rate fluctuation occurs, the test is stopped.

Following the failure of a test plate, a rate collection pan is weighed and placed at the plate location for a predetermined time interval. It is then re-weighed and placed again on the stand to collect a minimum of two additional rates at this location.

The rate of precipitation for any location on the stand is calculated by averaging the two rates collected prior to the test and the two rates collected following the test.

2.5.3.1.1 Precipitation Rate Distribution in Simulated Conditions

Clean test plates are placed on the test stand prior to the rate collection period, and are exposed to the simulated precipitation to verify that an even ice formation occurs over the entire test bed. If this visual inspection proves satisfactory, the rate collection period will begin. If this visual inspection proves unsatisfactory, the test stand must be repositioned under the spray device and the process repeated.

In order to verify the rate distribution on the test stand, a continuous rate-monitoring pan is replaced with a detailed rate distribution pan, which consists of four small pans of equivalent size. The area of the four small pans combined is similar to that of a standard rate collection pan. The small pans are weighed and placed at these locations and re-weighed at fixed intervals. The typical collection period for rate distribution is 60 minutes; however, this interval may be shorter if all tests have been completed within 60 minutes. The variation between the rate of any of the four small pans and that of the average rate of that location should not be greater than 10 percent.

Two examples of the detailed rate distributions are shown in Table 2.3. Both rate distributions were conducted in freezing drizzle, one at the low rate (5 g/dm^2/h), the other at the high rate (12.7 g/dm^2/h). The average precipitation rate over the entire position in the low rate example in Table 2.3 was 5.1 g/dm^2/h. The individual rates of the four smaller pans were 5.0, 4.9, 5.2 and 5.3 g/dm²/h, suggesting a maximum variation of 4.1 percent from the average rate over the entire position. The remainder of the detailed rate distributions appear in Appendix Q.

2.5.3.2 Natural Precipitation Conditions

Two rate collection pans per test stand are used to determine precipitation rates in natural conditions. Prior to the rate collection period, both pans are marked (upper and lower), and the inner bottom and sides of the each pan are wetted with Type IV anti-icing fluid to prevent blowing snow from escaping the pan. The wetted pans are then weighed to the nearest gram. The start time of the rate collection period is recorded (hr/min/sec) from the timepiece located near the rate station before leaving the trailer to place the pans on the test stand. The time delay necessary to proceed outside from the rate station is taken into consideration by the person(s) responsible for collecting precipitation rate data.

The pans are positioned in locations 6 and 7 (see Figure 2.4) and allowed to collect precipitation for 10-minute intervals in normal conditions and 5-minute intervals in periods of high precipitation rates and high winds. Prior to removal of the plate pans from the test stand for re-weighing, any accumulated precipitation on the lips and outer sides of each plate pan is carefully removed. The plate pans are then carried to the rate station for re-weighing. Upon entering the trailer, the exact time is noted. The new weights of the plate pans are recorded and the pans are brought back outside. This procedure is continued until the final plate on the test stand has failed.

The rate for any holdover time test in natural snow is obtained by computing the time-weighted average of the rates collected in the upper and lower pans over the duration of this particular test.

An example of the rate calculation method for tests in natural snow conditions is displayed in Figure 2.5. Typically, two collections pans are used for each test. The start and end times of the test are 10:15 and 10:45, respectively. Precipitation rates for one pan were collected at three periods during this test, indicated by t_1, t_2, and t_3 (minutes). The calculated rates for each collection period are indicated by R_1, R_2, and R_3 (g/dm²/h). In order to calculate the average rate for this pan, the following formula is then used:

$$\frac{(R_1 \times t_1 + R_2 \times t_2 + R_3 \times t_3)}{t_1 + t_2 + t_3} \qquad (2)$$

In the example shown in Figure 2.5, the rate is calculated as follows:

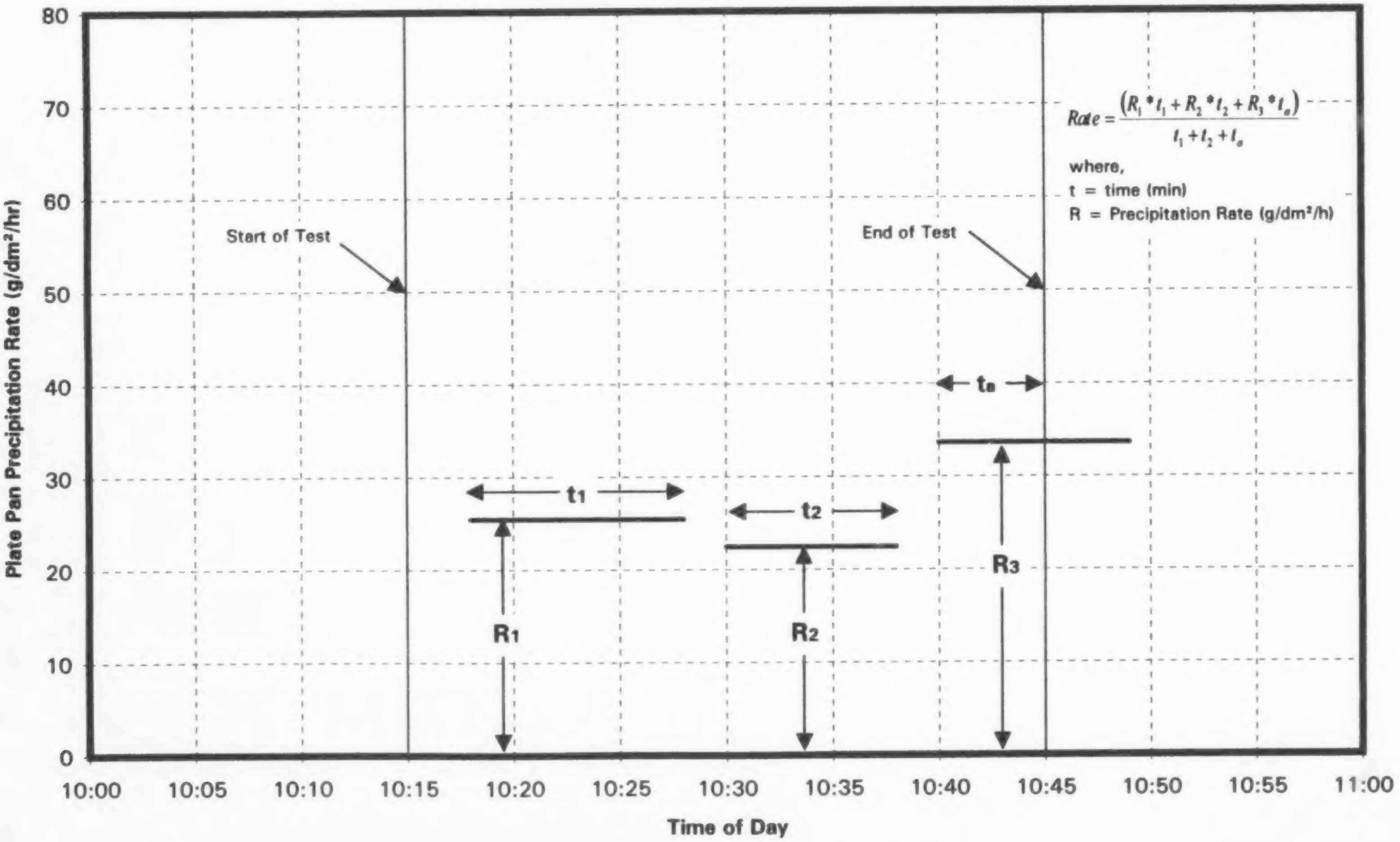
$$\frac{(25 \times 10 + 22 \times 8 + 34 \times 5)}{10 + 8 + 5}$$

The calculated average rate for this pan is 25.9 g/dm^2/h. The average rate for the other collection pan is calculated in similar fashion, and the average of the two rates is then taken.

FIGURE 2.5

CALCULATION OF OUTDOOR PRECIPITATION RATE

TYPICAL TEST



2.6 Data Forms

Two data forms were used to manually record data at Dorval during the 1998-99 winter season. The form used to record fluid failure times for each crosshair on the plates is shown in Table 2.4. The second form (Table 2.5) was used to record data relating to meteorological conditions during tests. One half of the form is designated for plate pan precipitation rate measurements, and the rest of the page is reserved for documentation of meteorological conditions and any changes to them that may occur during tests.

The data forms used in simulated precipitation tests at NRC are similar to those of the natural precipitation tests and are shown in Appendix C.

TABLE 2.5

METEO/PLATE PAN DATA FORM

VERSION 6.0 Winter 98/99

REMEMBER TO SYNCHRONIZE TIME WITH AES - USE REAL TIME

LOCATION: **DATE:** **RUN # :** **STAND # :**

HAND HELD VIDEO CASSETTE #:

PLATE PAN WEIGHT MEASUREMENTS *

PAN #	t TIME BEFORE (hh:mm:ss)	BUFFER TIME (Seconds)	t TIME AFTER (hh:mm:ss)	BUFFER TIME (Seconds)	w WEIGHT BEFORE (grams)	w WEIGHT AFTER (grams)	COMPUTE RATE $(\Delta w*4.7/\Delta t)$ $(g/dm^2/h)$

*measurements every 15 min. and at failure time of each test panel

METEO OBSERVATIONS **

TIME (hr:min)	TYPE (Fig. 4) ZR, ZL,S, SG IP, IC, BS, SP	CLASSIF. (See Fig. 3)	If SNOW, WET or DRY

**observations at beginning, end, and every 10 min. intervals. Additional observations when there are significant changes

TEMPERATURE AT START OF TEST ________ °C

WIND SPEED AT START OF TEST ________ kph

WIND DIRECTION AT START OF TEST ________ °

COMMENTS : ____

____

____

____

	PRINT	SIGN
WRITTEN & PERFORMED BY :	____________	____________
VIDEO BY :	____________	____________
TEST SITE LEADER :	____________	____________

TABLE 2.4

END CONDITION DATA FORM

VERSION 5.0 Winter 97/98

REMEMBER TO SYNCHRONIZE TIME WITH AES - USE REAL TIME

LOCATION: **DATE:** **RUN # :** **STAND # :**

RVSI Series # : ________________

CIRCLE SENSOR PLATE: u v w x y z

SENSOR NAME: __ __ __ __ __ __

DIRECTION OF STAND: ______ °

OTHER COMMENTS (Fluid Batch, etc):

____

____

____

____

____

____

____

____

	PRINT	SIGN
FAILURES CALLED BY :		
HAND WRITTTEN BY :		
TEST SITE LEADER :		

***TIME (After Fluid Application) TO FAILURE FOR INDIVIDUAL CROSSHAIRS (hr:min)**

Time of Fluid Application: ______ hr:min (U & X) ______ hr:min (V & Y) ______ hr:min (W & Z)

	Plate U			Plate V			Plate W		
FLUID NAME									
B1 B2 B3									
C1 C2 C3									
D1 D2 D3									
E1 E2 E3									
F1 F2 F3									
TIME TO FIRST PLATE FAILURE WITHIN WORK AREA									
CALCULATED FAILURE TIME (MINUTES)									
BRIX AT FAILURE									

	Plate X			Plate Y			Plate Z		
FLUID NAME									
B1 B2 B3									
C1 C2 C3									
D1 D2 D3									
E1 E2 E3									
F1 F2 F3									
TIME TO FIRST PLATE FAILURE WITHIN WORK AREA									
CALCULATED FAILURE TIME (MINUTES)									
BRIX AT FAILURE									

2.7 Fluids

2.7.1 General

Type I fluids were obtained from manufacturers in concentrated and standard dilution formulae. Each manufacturer sets its own standard dilution concentration based on performance requirements and cost. For example, one manufacturer's standard Type I fluid contains 57 percent glycol as delivered. During early months of the 1998-99 test season, Type I holdover time tests were conducted with standard dilution concentrations.

In July 1999, further Type I holdover time tests were conducted using further diluted solutions specific to particular test temperature requirements. Whenever fluid dilution is required, the concentrations are adjusted by mixing with hard water and are verified by measurement of the resulting solution's refractive index.

The hard water was produced according to AMS 1424. In order to produce 18 L of hard water, 6.54 g ± 1 g of calcium acetate monohydrate (Ca^{++}) and 5.04 g ± 1 g of magnesium sulfate heptahydrate (Mg) were weighed and added to 18 L of distilled water.

All holdover time testing conducted with Type I fluids at NRC in July 1999 used solutions *diluted to a 10°C buffer*. The 10°C buffer implies that for any test, the diluted test solution must possess a freeze point 10°C below that of the ambient test temperature. For example, if a given test was performed at 0°C, the fluid concentration of the test solution was adjusted to freeze at -10°C.

Type II and Type IV fluids in their neat concentrations contain a minimum of 50 percent glycol and are *thickened* by incorporating rheological additives to the fluid formulations. These additives modify the viscosities and flow properties. The modified formulations enable anti-icing fluids to assume a thicker films and to remain on the aircraft surfaces until the time of takeoff. The fluids are often delivered to air carriers in this form and are designated as neat (100 percent) fluids. Sometimes (mostly in Europe) neat Type IV fluids are mixed with water as follows:

- 75 percent neat formulation and 25 percent water by volume. This is designated Type IV 75/25; and
- 50 percent neat formulation and 50 percent water by volume. This is designated Type IV 50/50.

2.7.2 Fluid Tested

The de/anti-icing fluids used in 1998-99 testing were formulated with ethylene glycol (EG) or propylene glycol (PG).

A limited number of tests were conducted with Union Carbide XL54 fluid (EG), Inland Duragly-E (EG) and Duragly-P (PG) recycled fluids, and Octagon Octaflo Type I fluid (PG) during the 1998-99 winter in their standard concentrations.

Additional Type I testing, using fluids diluted to a 10°C buffer, were carried out using Union Carbide ADF (EG), Octagon Octaflo (PG), Octagon Octaflo EF (PG), Clariant EGI 1996 (EG), Inland Duragly-P (PG), Kilfrost DF Plus (PG), Home Oil Safetemp (PG), and Jarchem Jarkleer (PG). All fluids were provided to APS in their concentrated formulae. Subsequent dilution was performed with the addition of hard water.

One Type II fluid, Kilfrost ABC-II Plus (PG) (previously designated ABC-3+), along with 6 Type IV fluids - Union Carbide Ultra+ (EG), Octagon Max-Flight (PG), Clariant MPIV 1957 (PG), Clariant Safewing Four (PG), Kilfrost ABC-S (PG), and SPCA AD-480 (PG) - were tested in 1998-99.

The approximate delivery dates of the anti-icing fluids are shown in Figure 2.6. From this chart, it is apparent that the delivery date of the fluid affects the number of tests that were conducted in natural conditions with the fluid. For example, Clariant Safewing Four was delivered to APS in mid-December. Over 150 tests were performed with the fluid during the course of natural precipitation testing in 1998-99. On the other hand, less than 80 tests were conducted with Octagon MaxFlight, which was received in mid-February.

A list of the fluids requested for testing, along with the dates of receipt, batch numbers, and fluid freeze points has been compiled in Table 2.6.

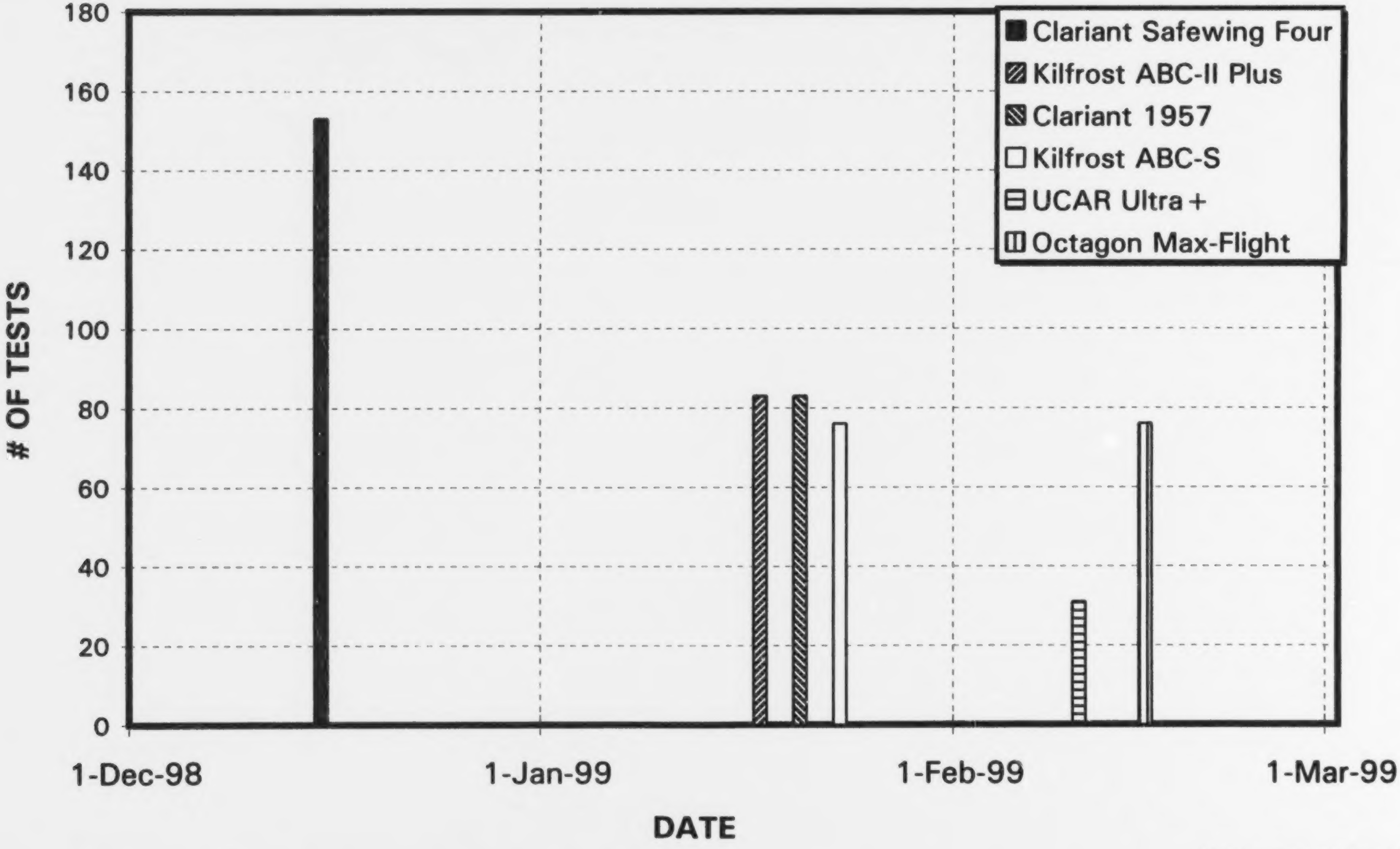
The fluids were received either in 20 L containers or in 200 L drums. For anti-icing fluids, the addition of hard water to obtain either 50/50 or 75/25 mixes was carried out by the fluid manufacturers in their production facilities.

2.7.3 Evolution of Type IV Fluids

Tests with several Type IV fluids were conducted in winters 1996-97 and 1997-98; however, some of these fluids are no longer available or have been changed. A summary of the changes is provided below:

FIGURE 2.6

EFFECT OF FLUID DELIVERY DATE ON THE NUMBER OF TESTS CONDUCTED IN NATURAL SNOW



CM1514/report/hot_subs/Figure 2.6
Final Draft 1.0, November 05

TABLE 2.6

FLUID REQUEST/RECEIPT

Fluid Manufac.	Fluid Type	Date Received	Quantity Ordered (Litres)	Brand Name Received	Quantity Received	Batch #	Brix Stated*	Brix Measured	Comments
Clariant	T I (Std.)	Decmeber 14, 1998	240	Safewing MP I 1938 50/50	240	81451	>28	29.5	
Clariant	*T II Neat (NS)*	Decmeber 14, 1998	100	Safewing MP II 1951	100	81451	36.5	35.5	*Non-sheared*
Clariant	T III		200						
Clariant	*T IV Neat (NS)*	Decmeber 14, 1998	40	Safewing Four	40	11665	37.5	35.5	*Non-sheared*
Clariant	T IV Neat	December 31, 1998	300	Safewing Four	300	11665	37.5	35.75	*Sheared*
Clariant	T IV 75/25	Decmeber 14, 1998	200	Safewing Four	200	11665	28.5	28	*Sheared*
Clariant	T IV 50/50	Decmeber 14, 1998	140	Safewing Four	140	11665	19	19	*Sheared*
Clariant	*T IV Neat (NS)*	January 25, 1999	40	Safewing MP IV 1957	40	11672	37	35	*Non-sheared*
Clariant	T IV Neat	January 25, 1999	300	Safewing MP IV 1957	300	11672	37	35	*Sheared*
Clariant	T IV 75/25	January 25, 1999	200	Safewing MP IV 1957	200	11672	28.5	27.5	*Sheared*
Clariant	T IV 50/50	January 25, 1999	140	Safewing MP IV 1957	140	11672	19	19	*Sheared*
Kilfrost	T I (Std.)	January 28, 1999	40	Kilfrost DF 50/50	50	B/173/1/99	29.1	29.25	
Kilfrost	T III		200						
Kilfrost	*T IV Neat (NS)*	January 21, 1999	40	Kilfrost ABC-II PLUS	50	PP1/1/99	35.6	36.25	*Non-sheared*
Kilfrost	T IV Neat	January 21, 1999	300	Kilfrost ABC-II PLUS	300	PP1/1/99	35.6	36.25	*Sheared*
Kilfrost	T IV 75/25	January 21, 1999	200	Kilfrost ABC-II PLUS	200	PP1/1/99	28.3	28.75	*Sheared*
Kilfrost	T IV 50/50	January 21, 1999	140	Kilfrost ABC-II PLUS	150	PP1/1/99	18.9	20	*Sheared*
Kilfrost	*T IV Neat (NS)*	January 28, 1999	40	Kilfrost ABC S	50	S 206/12/98	35.7	36.75	*Non-sheared*
Kilfrost	T IV Neat	January 28, 1999	300	Kilfrost ABC S	300	S 206/12/98	35.7	36	*Sheared*
Kilfrost	T IV 75/25	January 28, 1999	200	Kilfrost ABC S	200	S 206/12/98	28.3	29.5	*Sheared*
Kilfrost	T IV 50/50	January 28, 1999	140	Kilfrost ABC S	150	S 206/12/98	18.9	19	*Sheared*
Octagon	T I (Std.)	December 3,1998	140	Octaflo Concentrate	100	1198-02	51.5-53.25	>50	*Concentrate*
Octagon	T III		200						
Octagon	*T IV Neat (NS)*	Febuary 17, 1999	40	Octagon Max-Flight	40	F21-119	36.5	36.25	*Non-sheared*
Octagon	T IV Neat	Febuary 17, 1999	300	Octagon Max-Flight	300	F21-119	36.5	36.5	*Sheared*
Octagon	T IV 75/25	Febuary 17, 1999	200	Octagon Max-Flight	200	F21-119	28.75	29	*Sheared*
Octagon	T IV 50/50	Febuary 17, 1999	140	Octagon Max-Flight	140	F21-119	20	20	*Sheared*
SPCA	T I (Std.)		40						
SPCA	T III		200						
SPCA	*T IV Neat (NS)*		40						*Non-sheared*
SPCA	T IV Neat	January 4, 1999	300	AD 480	90	702 01.27.98	35.15	36.25	*Sheared*
SPCA	T IV 75/25	January 4, 1999	200	AD 480	60	702 01.27.98	27.15	28.5	*Sheared*
SPCA	T IV 50/50		140						
Union Carbide	T I (Std.)		240						
Union Carbide	T III		200						
Union Carbide	*T IV Neat (NS)*		40						*Non-sheared*
Union Carbide	T IV Neat	Febuary 9, 1999*****	300	UCAR ULTRA +	400	6-CHC-83-1 PM669	39.7	39.5	*Sheared*
Union Carbide	T IV 75/25		200						
Union Carbide	T IV 50/50		140						
Union Carbide	Fluid X	March 19, 1999	400	/	400	NA	NA		

Inland	Recycled Ethylene	January 8, 1999	200	3R-Duragly-E	20	121698	32	33.25	
Inland	Recycled Ethylene	January 14, 1999	/	3R-Duragly-E	20	11299	31.5	34	
Inland	Recycled Ethylene	Febuary 8, 1999	/	3R-Duragly-E	200	993001	33.3	32.75	
Inland	Recycled Propylene	Febuary 4, 1999	200	Duragly-P	200	112-798	38	32.75	

APS Aviation	Fluid X	January 14, 1999	/	I	20	1	/	41	
APS Aviation	Fluid X	January 14, 1999	/	I	20	2	/	41	

Kilfrost	*T IV Neat (NS)*	February 10, 1999	600	Kilfrost ABC S	600	S 235/1/99	NA		*Non-sheared*

Union Carbide: UCAR Ultra+ is not approved for use in diluted forms. Two additional Union Carbide Type IV fluids, UCAR Ultra IV and UCAR PG AAF, were shipped and tested for the first time in January 1998. However, these new fluids did not satisfy SAE fluid specifications.

Clariant/Hoechst: Type IV Hoechst MPIV 1957 was first tested in winter 1996-97. In winter 1997-98, the manufacturer changed its name to Clariant and reformulated the MPIV 1957 product. For clarity, the fluid tested in 1996-97 is referred to as Hoechst MPIV 1957 while the fluid tested in 1997-98 and 1998-99 is referred to as Clariant MPIV 1957. In addition, Clariant developed a new Type IV fluid, Clariant MPIV 2001, which was tested in 1997-98. In 1998-99, APS was provided with another Type IV fluid for testing, Clariant Safewing Four. Despite having tested the fluid in all conditions in 1998-99, Clariant will not produce the fluid in 1999-2000.

SPCA: SPCA AD-404 was tested in winters 1995-96 and 1997-98. A new Type IV fluid SPCA AD-480, was shipped for the first time in 1997-98. Additional testing with the AD-480 fluid was conducted in natural snow in 1998-99, due to a lack of data points at cold temperatures from the previous year. SPCA AD-404 is no longer available.

Type IV Octagon Max-Flight and Kilfrost ABC-S fluids have not been reformulated, and were tested during the past three test seasons (1996-97, 1997-98, and 1998-99).

The fluid viscosities of the different anti-icing fluids used in testing are discussed in section 5.1.1. In 1996-97 and 1997-98 holdover time testing, Type IV fluids consisted mainly of mid-range viscosity fluids. In 1998-99 testing, tests were conducted using fluids representative of the manufacturers' lowest recommended on-wing viscosity.

Different viscosity samples of the same Type IV fluid brand (sheared and unsheared) were provided by some fluid manufacturers. The effect of viscosity on holdover time is discussed in detail in Subsection 6.3.

Fluid-specific holdover time tables were developed and are described in detail in Subsection 5.6.

2.8 Personnel

The site at Dorval was staffed mainly by technicians or university students and supervised by APS staff. Depending on the rate and duration of precipitation, as many as four test stands were in use at Dorval. To operate four test stands, nine testers with the following responsibilities (see Appendix B, Attachment III for details) were used.

Test Site Leader (1):	Supervise and train site personnel, ensure site is functional, and ensure that test procedures are adhered to. Video record fluid failure as required.
End Condition (4):	Record end condition times for each crosshair.
Meteo (4):	Record meteorological conditions during every test.

Prolonged precipitation events require backup personnel, so a fairly large number of technicians were trained to perform experiments. This personnel reservoir was also needed because the same individuals were not always available for tests due to other obligations. Due to the nature, scale, and schedule of the testing (both holdover time and full-scale) and the requirement to keep costs to a minimum, a pool of students was considered to be the best option for the manpower requirements of these tests.

The use of personnel for the cold chamber tests was slightly different. To ensure that the cold chamber facility was used at all times, dedicated technicians were often assigned specific tasks. For example, fluids were prepared, mixed, cooled and replenished after every test. During cold-soak testing, a technician was dedicated to ensuring the cooling unit was maintained in operational status and the cold-soak boxes were properly thermostatted. To ensure accurate precipitation rate measurements, the rate measurement procedure was semi-automated and a technician was assigned the task of calculating and displaying printed summaries of the precipitation rates. A computer and printer were dedicated for this process alone.

In order to obtain consistent results from fluid failure calls, the same individual has recorded the end conditions for NRC freezing precipitation tests since the 1996-97 test season. This individual, with pilot experience, was also available during all natural snow tests conducted at Dorval Airport and supervised most of the failure calls.

2.9 Analysis Methodology

2.9.1 General

This section of the report describes the various categories of precipitation and the precipitation rate limits used during the course of holdover time testing. The process of data analysis used in the evaluation of fluid holdover times is also described.

2.9.2 Descriptions of Data Ranges and Precipitation Definitions

The test program developed to measure fluid failure times was carried out under five general categories of precipitation:

- Natural snow;
- Freezing drizzle;
- Light freezing rain;
- Freezing fog; and
- Rain on a cold-soaked surface.

Tests were conducted over temperature and precipitation rate ranges specific to each category of precipitation. A multi-variable regression procedure was used to evaluate fluid holdover times (first presented in Transport Canada report TP 13131E (8)). This procedure is based on the refinement of an equation for a curve that best represents the fluid failure time test data, and the solution of that equation at the upper and lower limits of a defined precipitation range. To support this procedure, precipitation rate limits for each specific category of precipitation were defined, reviewed and approved.

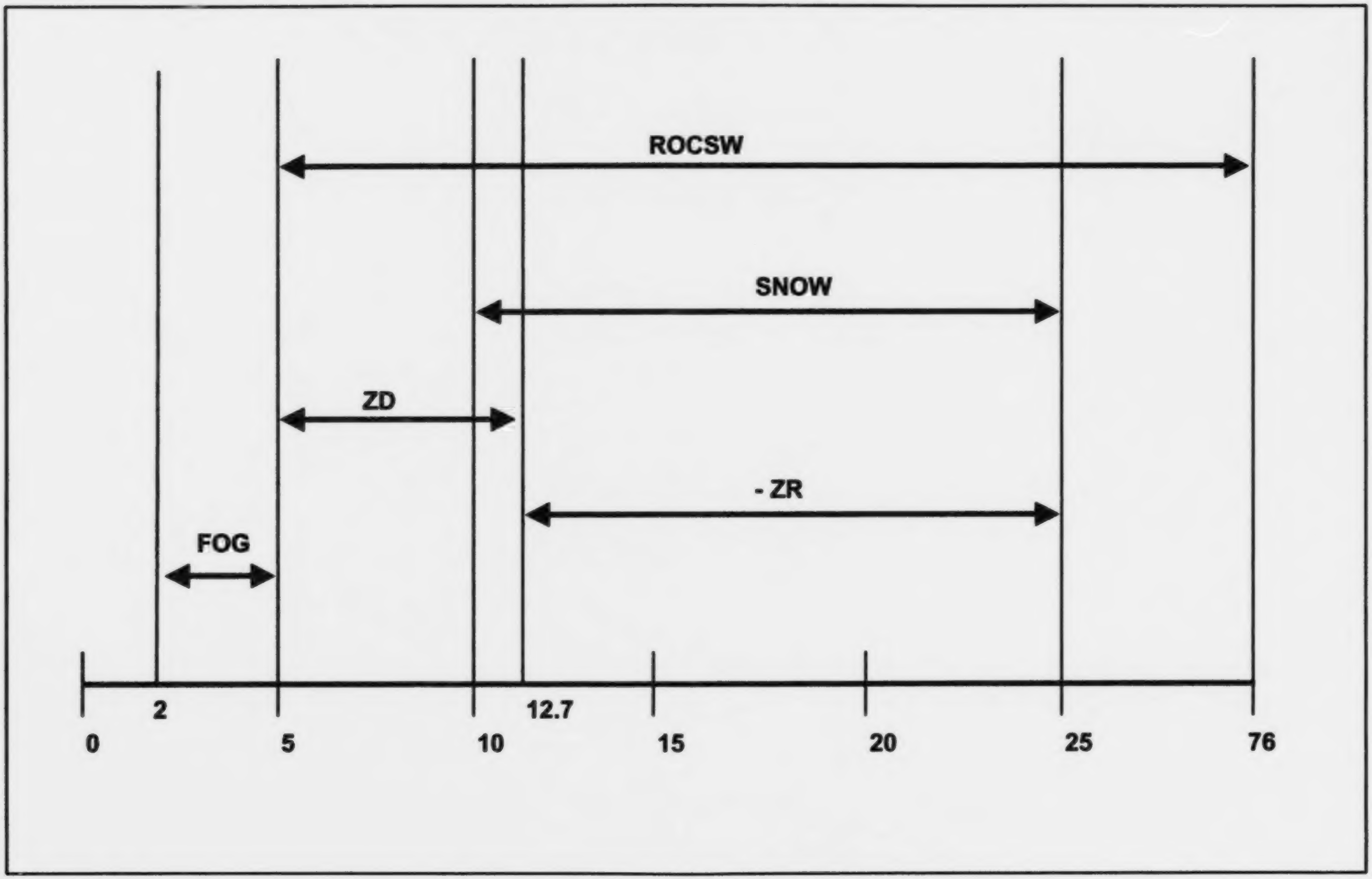
The precipitation rate limits used for the evaluation of holdover times are represented schematically in Figure 2.7. Detailed definitions and explanations of the data types and ranges are described in the following subsections. Meteorologically accepted definitions of these conditions were outlined in Table 2.1.

2.9.2.1 Natural Snow

All fluid failure tests in natural snow were conducted at the APS Dorval Airport test site. Data were collected for precipitation rates that ranged from less than 10 $g/dm^2/h$ to more than 25 $g/dm^2/h$. However, upper and lower holdover times for each cell in this column were determined at rates of 10 and 25 $g/dm^2/h$, respectively.

FIGURE 2.7

DATA RANGE USED FOR EVALUATION OF HOLDOVER TIME LIMITS


ROCSW
SNOW
ZD
- ZR
FOG
0
2
5
10
12.7
15
20
25
76

If precipitation rates less than the lower limit (light snow) are encountered in an actual operation, the upper time limit of the holdover time range can be selected for use.

The upper precipitation rate limit (25 g/dm^2/h) corresponds to the onset of heavy snow. Above this rate, it is standard practice to refer to the cautionary note included in the holdover time tables indicating that the time of protection will be shortened in heavy weather conditions, (i.e., heavy precipitation, or high moisture content).

2.9.2.2 Freezing Drizzle

Freezing drizzle is considered to occur over the range of 0 to 12.7 g/dm^2/h. The upper limit in this range, while not specifically defined in Table 2.1, has been adopted based on discussions with meteorological experts and aircraft operators on the SAE G-12 Holdover Time Subcommittee.

For test purposes, the precipitation rate spectrum for freezing drizzle is constrained to rates between 5 and 12.7 g/dm^2/h, inclusive. This range corresponds to heavy drizzle and has been chosen to provide aircraft operators with a greater margin of safety. A caution note is included in the holdover time tables indicating that if positive identification of freezing drizzle is not possible, the light freezing rain holdover time is recommended for use.

2.9.2.3 Light Freezing Rain

With reference to the holdover time tables, freezing rain conditions span the range of precipitation rates from 12.7 to 25 g/dm^2/h, inclusive. This range falls in the category of light freezing rain and is the only freezing rain category considered, as operations in periods of moderate or heavy freezing rain are deemed unsafe.

2.9.2.4 Freezing Fog

The precipitation rate limits for freezing fog were arrived at with input from meteorologists from the National Research Council, who helped define an important parameter in the study of fog referred to as the *Liquid Water Content* (LWC). This quantity, expressed in density terms as the mass of water in grams contained in one cubic meter of air, can generally assume values in the range of 0.2 to 0.6 g/m^3. The precipitation rate for fog, referred to as *fog deposition* or simply as *deposition*, is given by the empirical expression,

Deposition = LWC x Wind Velocity x Sin 10° x Collection Efficiency (3)

where the Sin 10° term accounts for the 10° inclination of the test plates into the direction of the wind.

The meteorological circumstances (LWC value and wind speed), and the speed and orientation of the airfoil relative to the wind (stationary or taxiing), contribute to uncertainties in the values that the variables in the equation can assume.

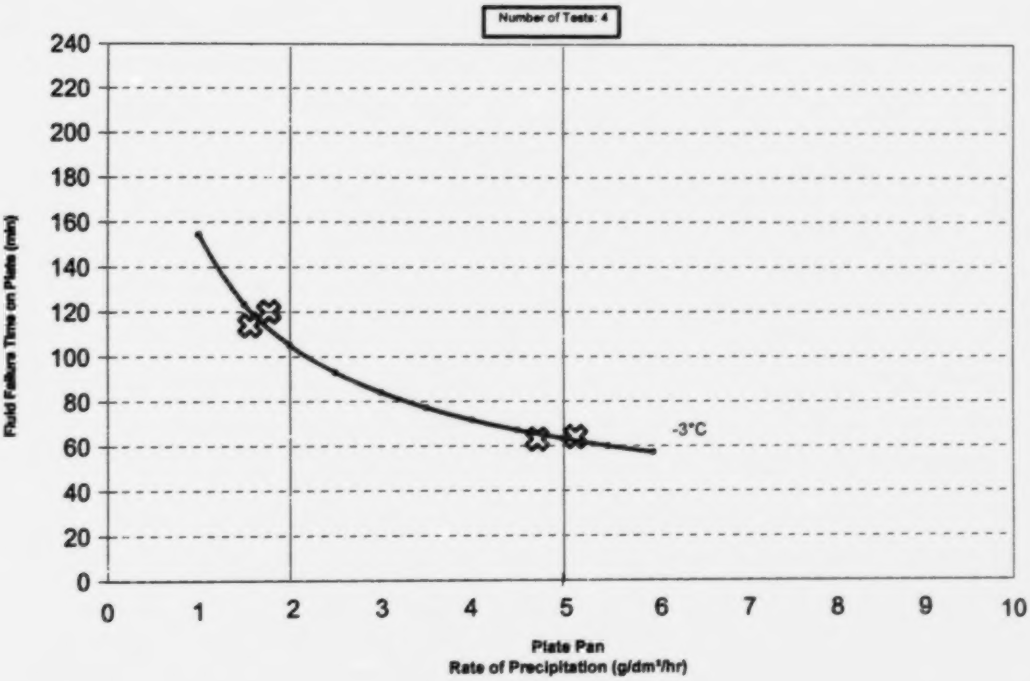
The upper and lower holdover times for freezing fog were determined subjectively from the test data in previous years. It was agreed upon (at the 1997 Chicago SAE G-12 Holdover Time Subcommittee meeting) that the lower and upper holdover times for fog be evaluated at rates of 5 g/dm^2/h and 2 g/dm^2/h, respectively. In Vienna, during the 1998 SAE G-12 Holdover Time Subcommittee meeting, it was felt that 2 g/dm^2/h was not indicative of low rate natural fog. As a result, the upper holdover times in each of the freezing fog cells of the holdover time tables were left untouched for the 1998-99 winter operating season. During a meeting of the Workgroup on Laboratory Methods to Derive Holdover Time Guidelines in Montreal in March 1999, it was again agreed upon that the rate of 2 g/dm^2/h would be used in subsequent holdover time testing in order to determine the upper holdover time limit in freezing fog conditions.

Substantial improvements were made to the freezing fog spray delivery system during the past test season. This afforded improved control over fog deposition rates during 1998-99 indoor tests. In previous years, freezing fog was sprayed horizontally from the walls of the chamber onto the test plates. In 1998-99, the spray assembly was positioned overhead the test stand, allowing the freezing fog to be sprayed vertically down onto the plates.

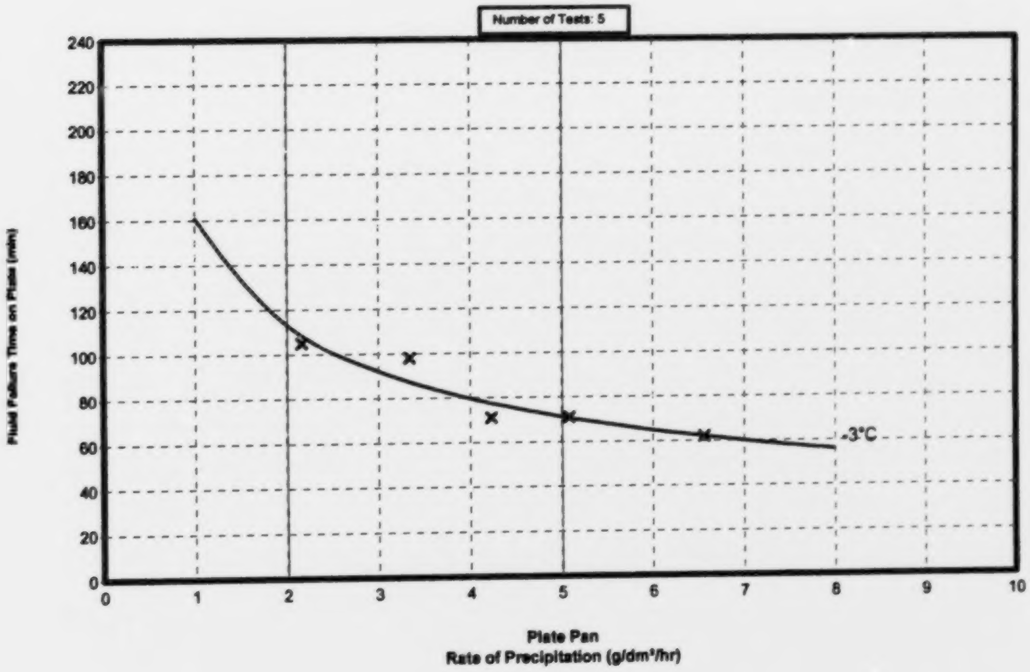
Figure 2.8 shows the results of one fluid (Kilfrost ABC-S 75/25) tested during 1997-98 and 1998-99 using the different freezing fog spray systems. The data points from 1998-99 tests appear much closer to the rate limits of 2 and 5 g/dm^2/h than those of 1997-98 tests. The regression-generated holdover times of the two samples were similar – 1:05 to 1:50 in 1998-99 compared to 1:10 to 1:50 in 1997-98. This slight reduction in holdover time is most likely a result of the low viscosity sample that was used in 1998-99 testing.

FIGURE 2.8

Comparison of Fog Results from Two Spray Delivery Systems



EFFECT OF RATE OF PRECIPITATION ON FAILURE TIME
KILFROST ABC-S TYPE IV 75/25 AT -3°C (LOW VISCOSITY)
SIMULATED FREEZING FOG
1998-99



EFFECT OF RATE OF PRECIPITATION ON FAILURE TIME
KILFROST ABC-S TYPE IV 75/25 AT -3°C
SIMULATED FREEZING FOG
1997-98

2.9.2.5 Rain on a Cold-Soaked Surface

Data used for the evaluation of holdover times for this category of precipitation were limited to precipitation rates ranging from 5 to 76 g/dm^2/h, which encompasses drizzle (5 to 12.7 g/dm^2/h), light rain (12.7 to 25 g/dm^2/h), and moderate rain (25 to 76 g/dm^2/h). The heavy rain category is covered by the caution note at the bottom of the holdover time table regarding heavy weather conditions.

2.9.3 Protocol for the Determination of Holdover Times

Each cell in a holdover time table represents a range of time during which a fluid at a specified concentration will provide protection for a particular temperature range in a particular category of precipitation. The Type II and Type IV holdover time tables are composed of a maximum of 45 cells. Each cell contains a lower and upper time limit (except for frost) for a maximum of 81 time values.

Cell holdover time values are determined by plotting Failure Time versus Rate of Precipitation and recording the failure time at two pre-selected rate limits. In previous years, several protocols were employed in the determination of holdover times. Due to the subjective natures of these different protocols, different interpretations of the data were possible. A multi-variable regression approach was subsequently devised in 1996-97 (see Transport Canada report TP 13131E (8)) and has been used to evaluate fluid holdover times for the past three test seasons.

2.9.3.1 Multi-variable Regression Protocol

Data corresponding to each cell in the holdover time table were assembled and sorted according to precipitation type, fluid manufacturer, dilution factor, and temperature range. The data for each fluid and each cell in the holdover time table were plotted. The data points on each plot were used to fit an equation of the form

$$t = cR^a \tag{4}$$

where

t = Time (minutes)
R = Rate of precipitation (g/dm^2/h)
a,,c = coefficients determined from the regression.

The coefficient a gives the rate dependency of the failure time.

Plots of **Log t** versus **Log R** are shown in Figure 2.9. The plots contain data from one temperature range, for one Neat Type IV fluid in light freezing rain conditions. The best-fit regression line is superimposed onto the plot and was obtained from the analysis using the lowest temperature in the temperature range from which the data were chosen.

The same data plotted on a linear scale (failure time **t** versus precipitation rate **R**) are shown in Figure 2.10. The curve, generated from the power law form of the equation using the coefficients determined from the fit, is superimposed onto the plot. The holdover time range is determined from the intersections of the curve with the precipitation rate limits defined for snow.

The holdover times for this fluid at -10°C are 20 minutes at 10 g/dm^2/h and 35 minutes at 25 g/dm^2/h, establishing the holdover time range for this particular fluid. This illustrates the general approach used in the determination of a fluid holdover time range for any given cell in the holdover time table.

Appendix G lists the results of all the regression analyses performed and includes all the corresponding equations with their associated coefficients determined, form each analysis and their associated output summaries.

The categories of precipitation are separated into five groups: natural snow, freezing drizzle, light freezing rain, freezing fog, and rain on a cold-soaked surface. Each group was subject to a slightly modified version of the general equation given above, as described in the following subsections.

FIGURE 2.9

EXAMPLE OF REGRESSION METHOD ON LOG-LOG CHART
EFFECT OF TEMPERATURE AND RATE OF PRECIPITATION ON FAILURE TIME
CLARIANT SAFEWING 1957 TYPE IV NEAT
LIGHT FREEZING RAIN
1998-99

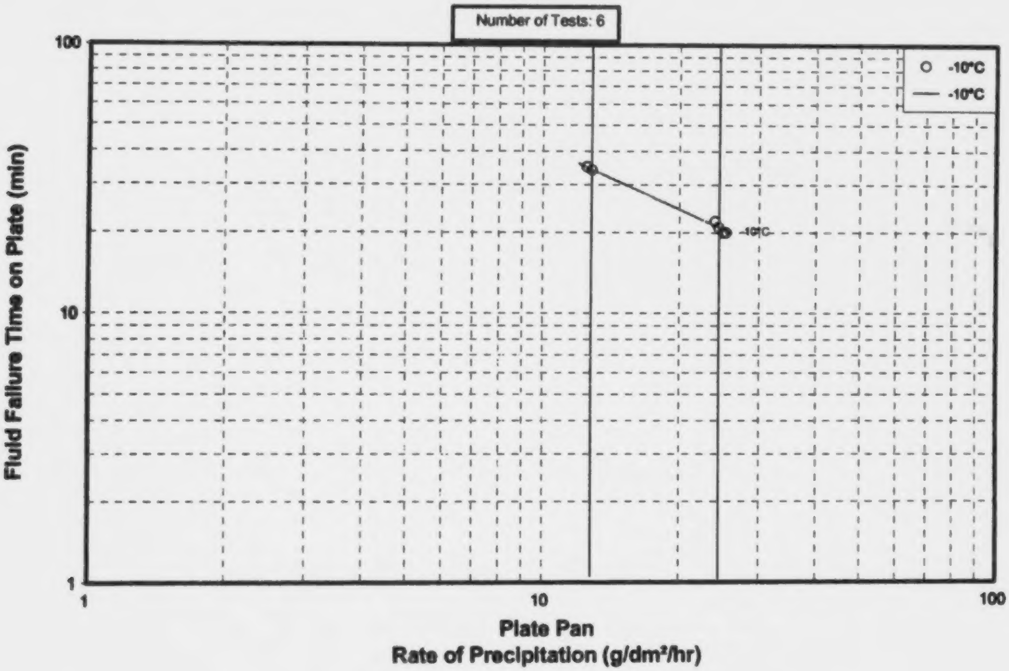
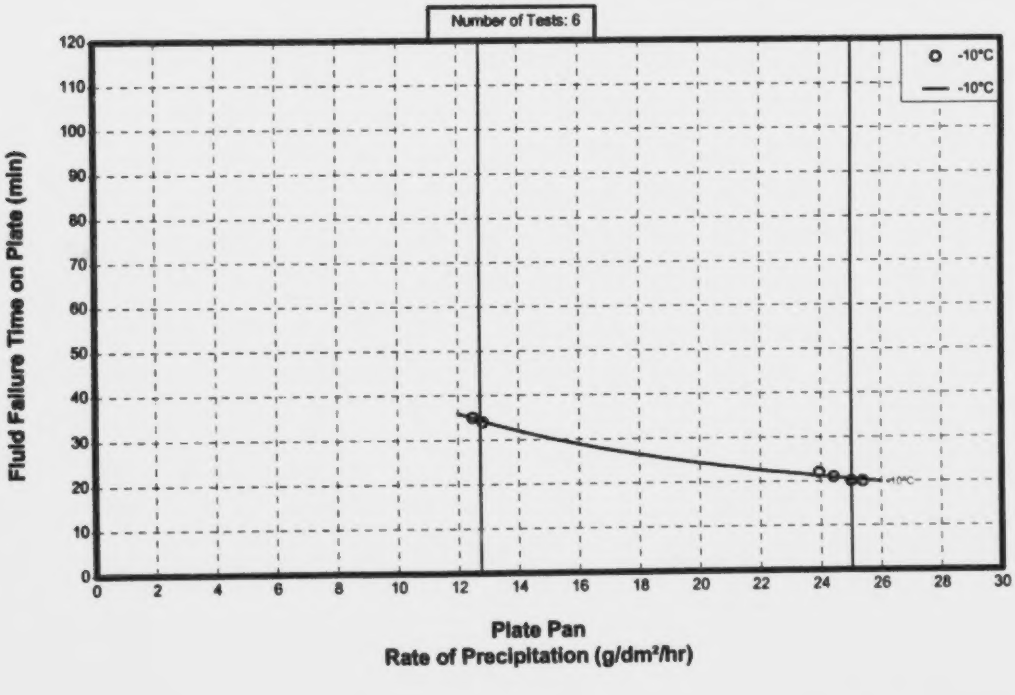


FIGURE 2.10

EXAMPLE OF REGRESSION METHOD ON STANDARD CHART
EFFECT OF TEMPERATURE AND RATE OF PRECIPITATION ON FAILURE TIME
CLARIANT SAFEWING 1957 TYPE IV NEAT
LIGHT FREEZING RAIN
1998-99



2.9.3.1.1 Light Freezing Rain and Freezing Drizzle

Equation 4 is used to treat the data in these categories of precipitation.

- Tests in freezing drizzle and light freezing rain were conducted at predetermined temperature limits (-3 and -10°C during the past year). The best-fit curves for data corresponding to a given cell in the holdover time table in these conditions were also obtained by using the most restrictive (lowest) cell range temperature.

- The exception to this was made for the case of the temperature range above 0°C. Experiments for freezing drizzle and light freezing rain could not be performed artificially at temperatures above 0°C, and as such, the equation could not be calculated at the most restrictive temperature of 0°C. Therefore, holdover times for this temperature range were obtained by using the same values calculated at -3°C.

2.9.3.1.2 Simulated Freezing Fog

The same method used to evaluate freezing fog data in 1996-97 (see Transport Canada report TP 13131E (8)) was also used to evaluate this year's freezing fog data. Equation 4 is used to treat data in this category of precipitation.

2.9.3.1.3 Natural Snow

The general form of the regression equation was modified for natural snow by substituting 2-T for the variable T, in order to prevent taking the log of a negative number as natural snow can occur at temperatures approaching 2°C.

$$t = cR^{a}(2-T)^{b}. \qquad (5)$$

- Best-fit curves were plotted for each fluid in each cell of the snow column, using the most restrictive (lowest) temperature for that cell. For example, in cases of natural snow tests conducted at ambient temperatures above 0°C, the value of temperature used in the fitting procedure was 0°C.

- The upper and lower holdover time values were determined from the points at which the best-fit curve intersects the lower and upper precipitation limits, respectively.

2.9.3.1.4 Rain on a Cold-Soaked Wing

The same method for the evaluation of holdover times in light freezing rain and freezing drizzle was used for this category of precipitation.

2.9.4 Determination of Generic and Fluid-Specific Holdover Times

At the SAE Holdover Time Subcommittee meeting in Chicago in July 1997, Type IV fluid holdover times obtained using the multi-variable regression protocol of data analysis were presented. Wide variations in fluid performance among the different Type IV fluid brands forced the development of a *generic* or *SAE* Type IV holdover time table as well as *fluid-specific* Type IV holdover time tables. *Generic* and *fluid-specific* holdover time tables have subsequently been generated in 1997-98 and 1998-99.

More recently, during winter 1998-99 testing, a new Type II fluid also demonstrated superior performance in some conditions. This resulted in the development of a *fluid-specific* holdover time table for this fluid.

2.9.4.1 Generic or SAE Holdover Time Table

From the procedure outlined in Subsection 2.9.3.1, the plots containing the fluid test data from 1998-99 tests, illustrating the effect of fluid brand and rate of precipitation on holdover time, were assembled (see Appendix F). In addition, the holdover time results from tests conducted in 1996-97 and 1997-98, using the same regression method of analysis, were combined and are included in Appendix R. The combined results were then compared on a cell-by-cell basis to determine the worse possible holdover time values in each cell of the holdover time table. The *generic or SAE* holdover time table for Type IV fluid (approved for use in 1999-2000), which contains the worst performing fluid holdover time values from 1996-97, 1997-98, and 1998-99 tests, is included in Section 5.

Although no single *worst-case* fluid exists, the concept of a *worst-case* or *generic* fluid possessing performance characteristics that reflect the worst-case holdover times is useful for the purpose of discussion. The terms *generic or SAE* are used in the remainder of this report and refer to a hypothetical fluid that exhibits the *worst-case* holdover time performance.

2.9.4.2 Fluid-Specific Holdover Time Tables

Fluid-specific holdover time table development was prompted by the fact that certain Type IV fluid brands were observed to significantly outperform other fluids under conditions corresponding to specific cells in the holdover time tables. In general, any one fluid brand does not globally outperform the other fluid brands, but rather does so at a specific dilution, temperature range, and/or category of precipitation.

At the Chicago meeting in 1997, most members of the SAE G-12 Holdover Time Subcommittee did not favour *fluid-specific* tables. However, significant reductions to holdover times for the cells corresponding to the most common Type IV fluid usage convinced the committee of the need to consider the development of *fluid-specific* and *generic* tables. Furthermore, some members wanted to take advantage of the significant benefits exhibited by some fluids in certain conditions.

For use in 1997-98 and 1998-99 winter operations, *fluid-specific* holdover times were adopted for the three most commonly occurring precipitation categories in the holdover time tables: freezing drizzle, light freezing rain and snow. For the other categories of precipitation (freezing fog, rain on cold-soaked surfaces and frost), *generic* holdover times were adopted.

For use in 1999-2000 winter operations, *fluid-specific* holdover time values were adopted for all categories of precipitation with the exception of frost.

A summary of the steps to determine specific values for each fluid is provided below:

- The method used to determine holdover times is generally the same as was agreed upon in Chicago in 1997 at the SAE G-12 Holdover Time Subcommittee meeting;
- For each cell of the holdover time tables, four tests are typically conducted at the lowest temperature in the temperature range for that cell. Two tests are conducted at the low precipitation rate condition and two at the high precipitation rate condition, for a total of four tests per cell;
- For each cell of the holdover time table (except frost), a best-fit power law curve for each fluid was developed from the tests conducted at the low and high precipitation rate condition of that cell;
- Regression-generated holdover times were rounded off to the nearest whole "5" digit. For example, 55.1 to 57.4 minutes was rounded down to 55 minutes; 57.5 to 59.9 minutes was rounded up to 60 minutes;

- In all cases where the regression-generated holdover times were below 10 minutes, the numbers were rounded down as a precautionary measure. For example, 9 minutes was rounded down to 5 minutes;

- Cold-soaked wing and freezing fog fluid-specific values were used if the data were available. In the past, fluid-specific values were adopted in the snow, freezing drizzle and light freezing rain columns of the holdover time tables only; and

- Values were capped at 2 hours for all precipitation conditions except freezing fog, which were capped at 4 hours.

Photo 2.1

View of Dorval Test Site and Associated Equipment

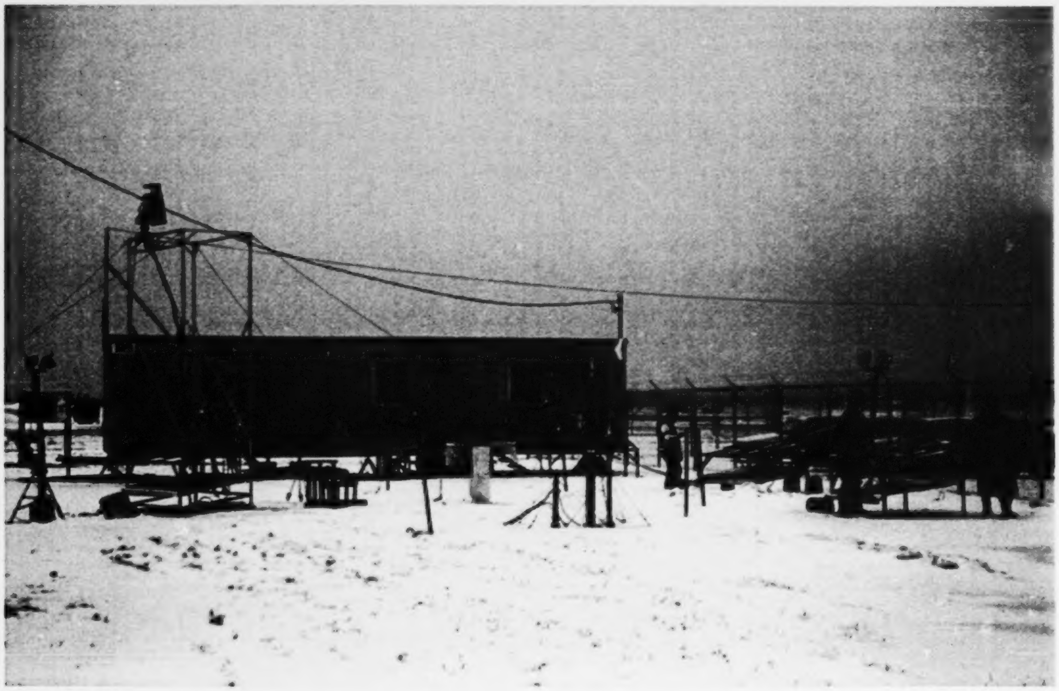


Photo 2.2

Environment Canada's Weather Observation Station at Dorval Airport

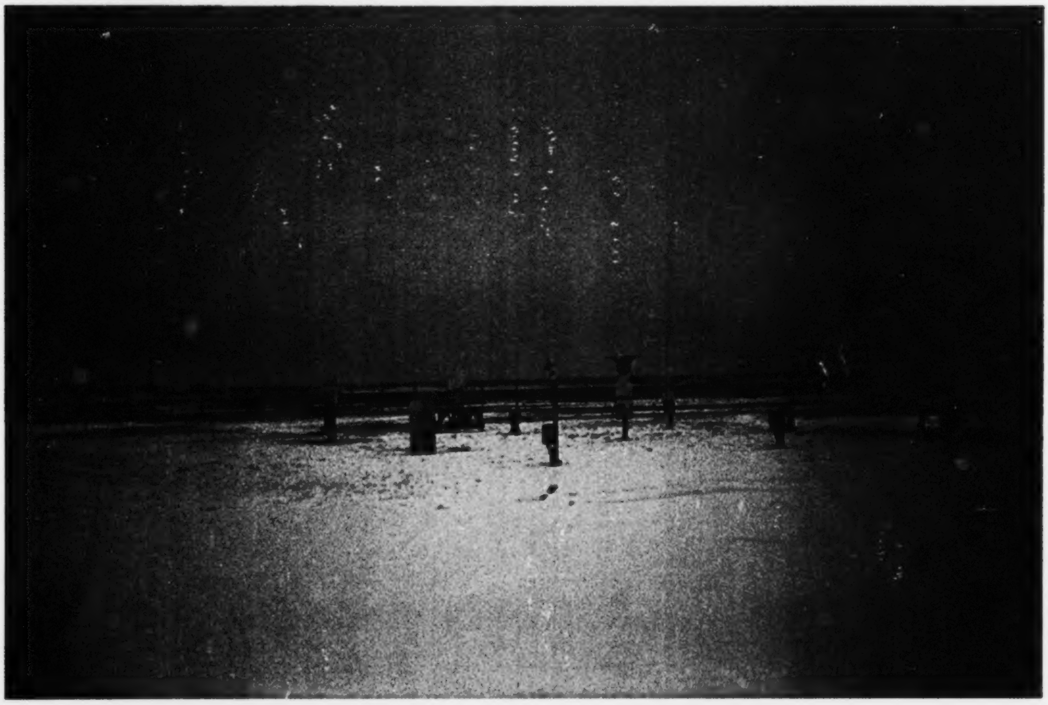


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Photo 2.3
Outdoor View of NRC Climatic Engineering Facility

Photo 2.4
Inside View of Small End of Climatic Engineering Facility

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Photo 2.5
Inside View of Large End of Climatic Engineering Facility

Photo 2.6
Sprayer Assembly Used at NRC

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Photo 2.7
Sprayer Nozzle

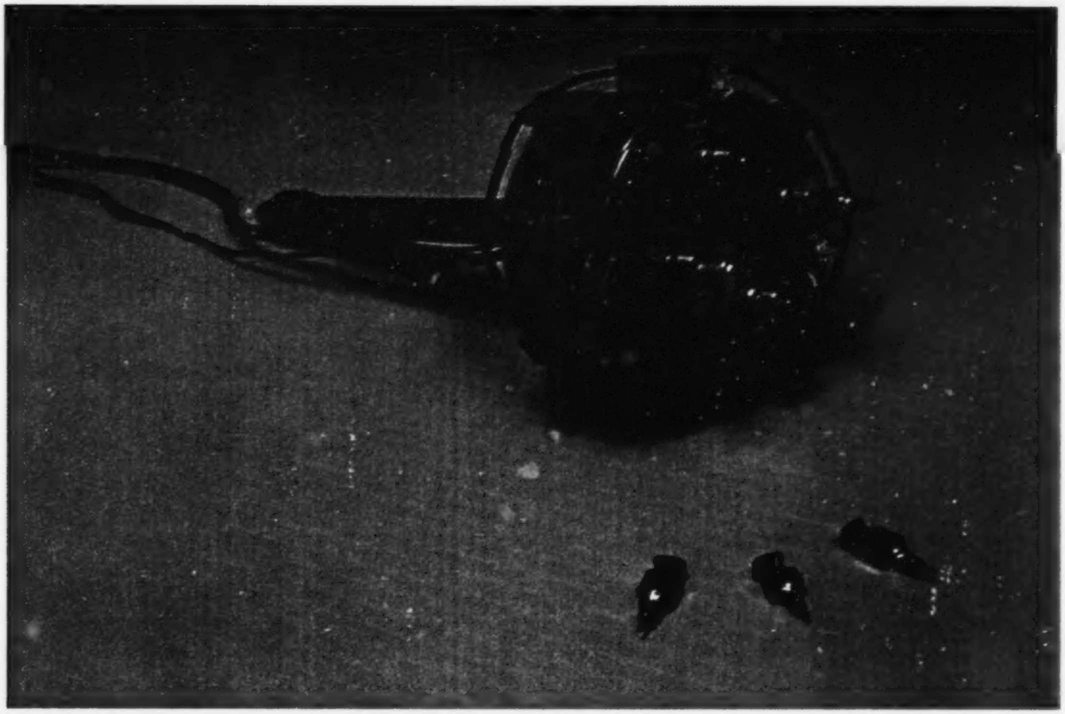

Photo 2.8
Optical Gauge by HSS to Measure Droplet Size

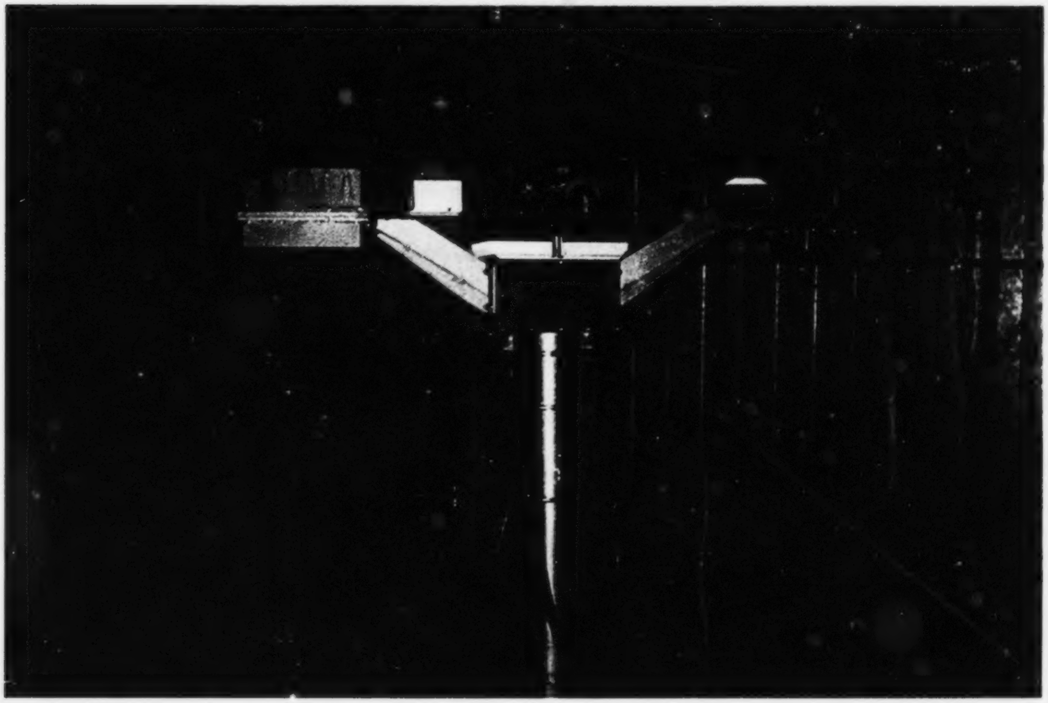

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Photo 2.9
Examples of Droplet Sizes Produced by NRC Spray System

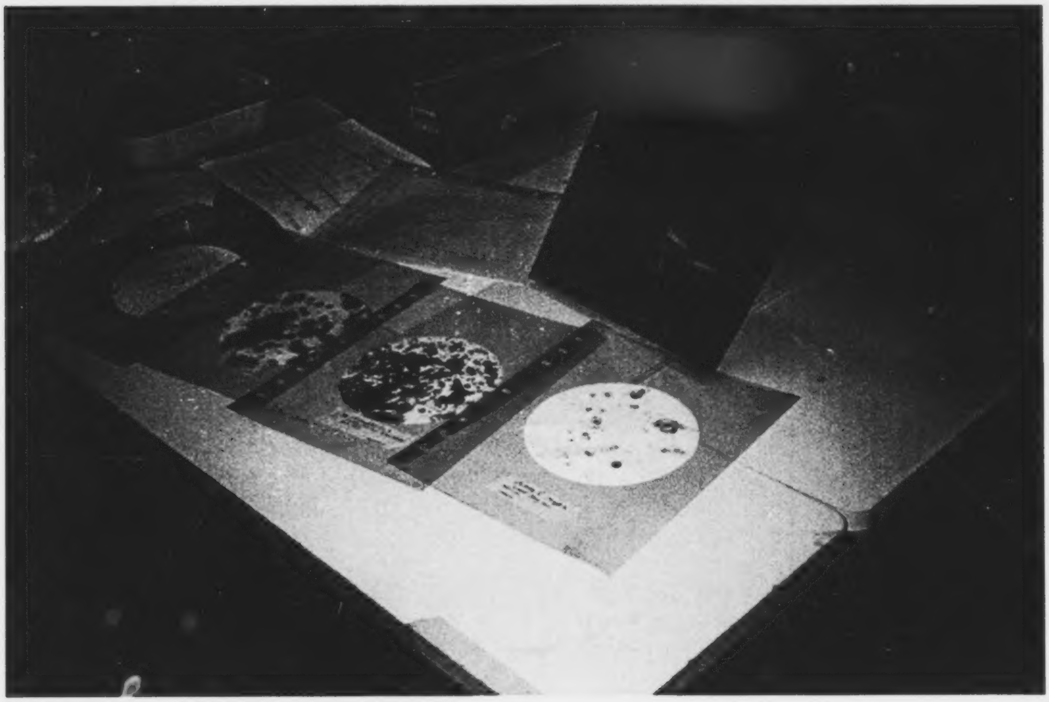

Photo 2.10
Test Plates Mounted on a Stand

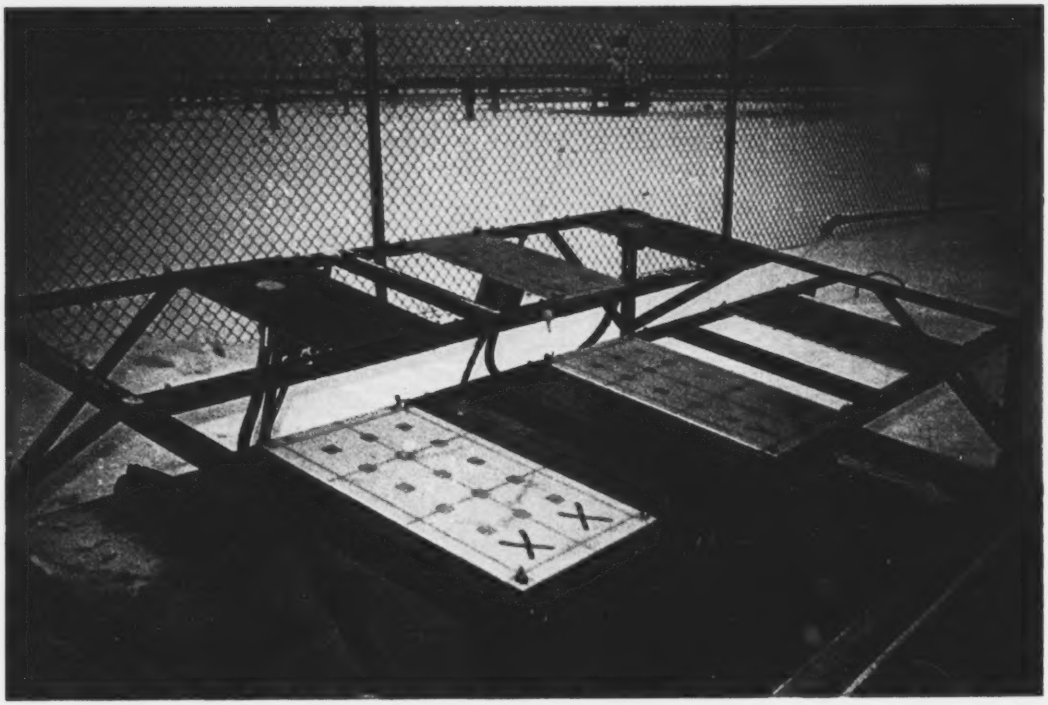

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Photo 2.11

Collection Pans Used Indoors at NRC

Photo 2.12

Cold-Soak Boxes Cooling Unit

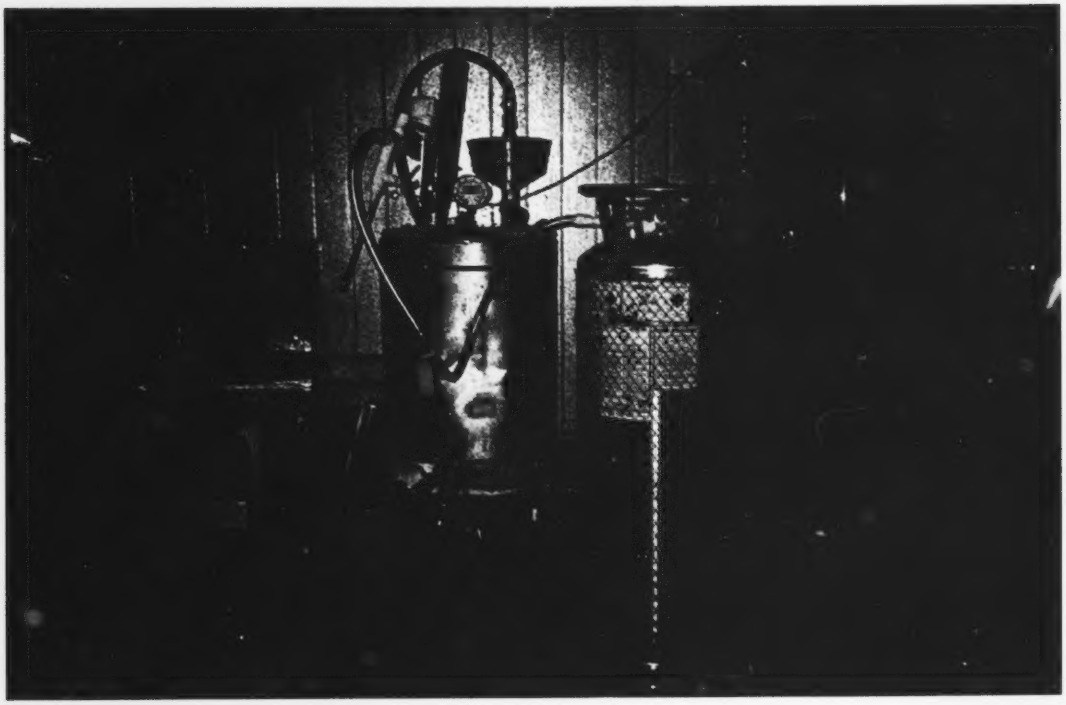

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Photo 2.13
New Cooling Unit for Cold-Soak Boxes

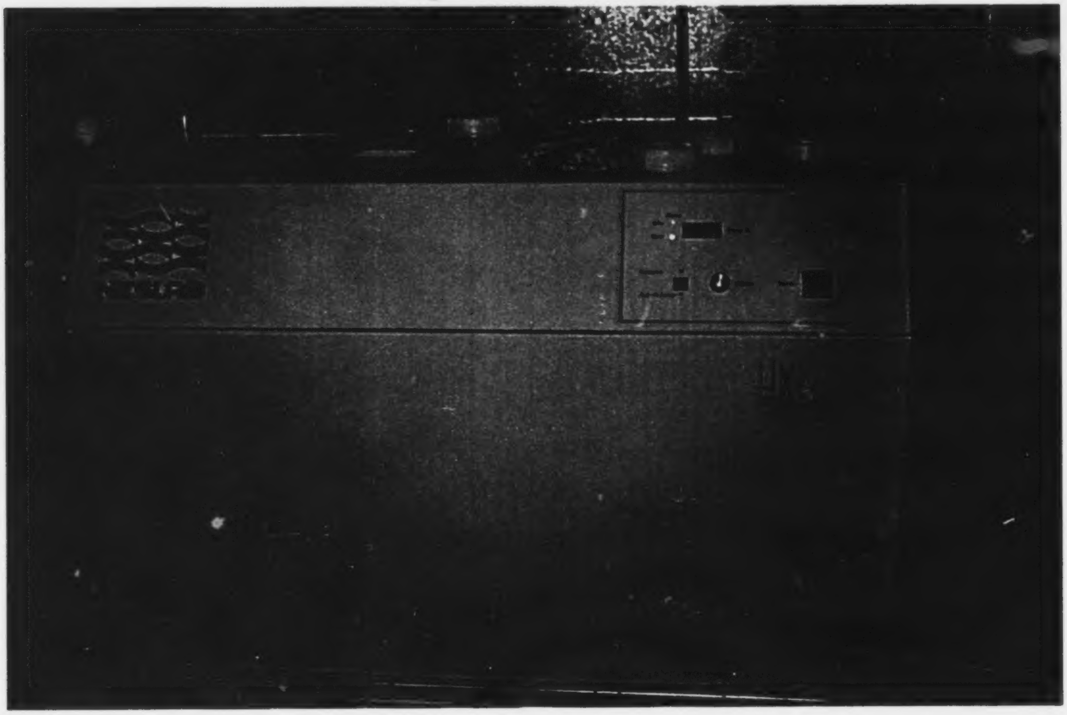

Photo 2.14
Digital Clock Used in Holdover Time Testing

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Photo 2.15
Misco Refractometer Used to Measure Freeze Point

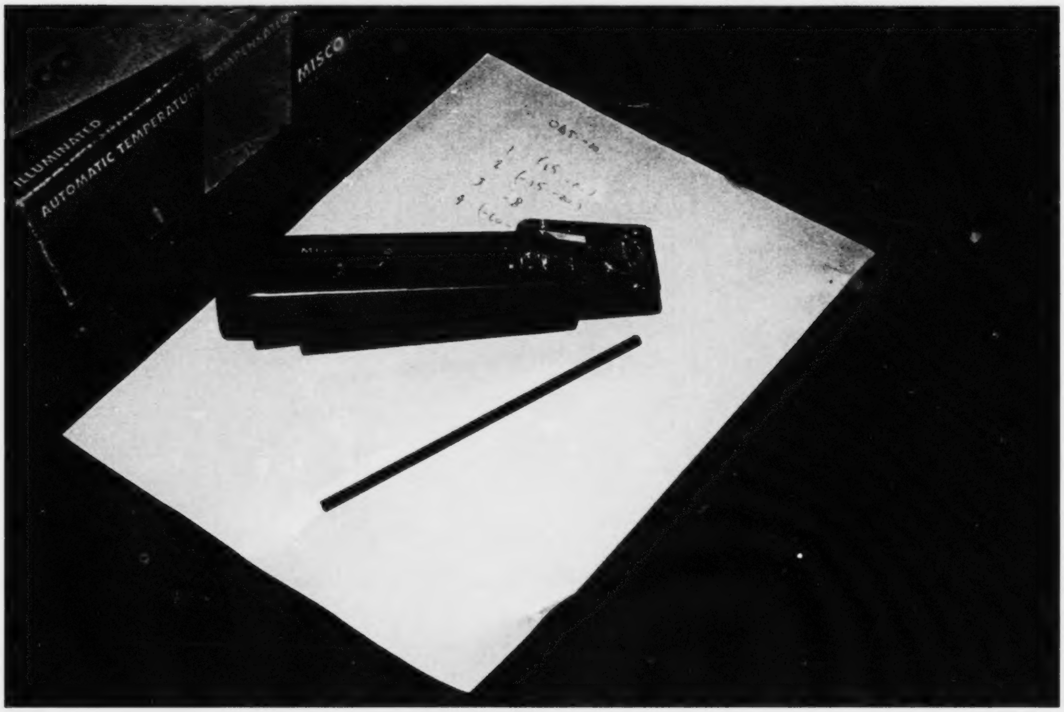
ILLUMINATED
AUTOMATIC TEMPERATURE COMPENSATED
MISCO

Photo 2.16
Spar/Cox Ice Detection Unit

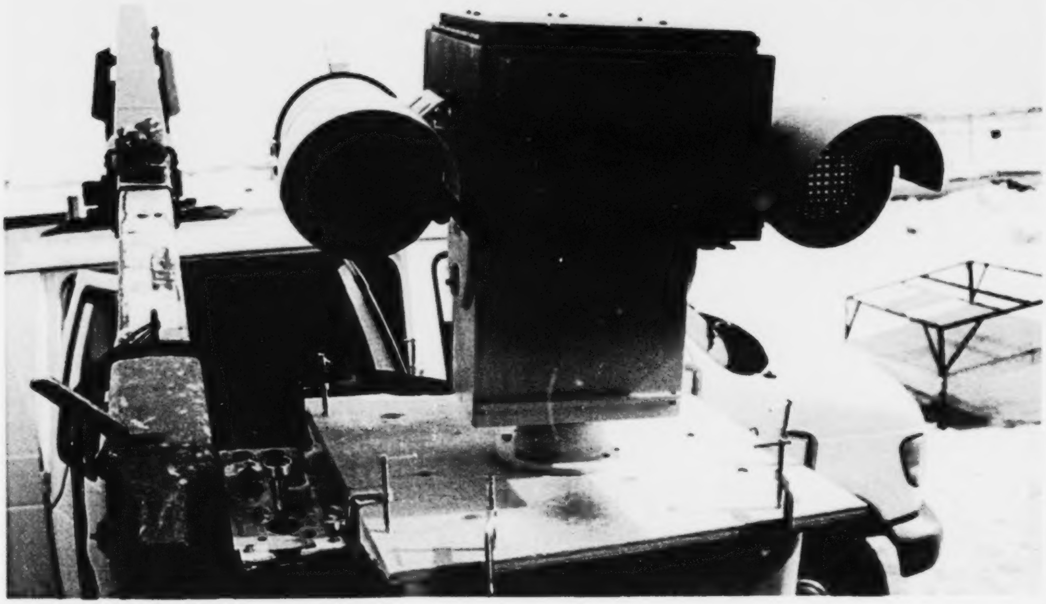

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Photo 2.17

AES Automated Weather Station Instruments

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3. DESCRIPTION OF DATA

This section provides a summary of the number of tests conducted for natural snow, simulated light freezing rain, simulated freezing drizzle, simulated freezing fog, and rain on cold-soaked surfaces. Breakdowns are provided for quantity of tests performed versus fluid type and distributions of weather parameters such as temperature, precipitation rate, and wind speed.

Natural snow tests were conducted at the APS test site, located at Dorval Airport. A total of 671 usable tests were conducted over the 1998-99 winter season.

Simulated light freezing rain, drizzle, fog and rain on cold-soak box tests were conducted at NRC's CEF in Ottawa.

3.1 Dorval Natural Snow Tests

3.1.1 Data Acquisition

The test plan developed for experiments to be conducted in natural snow conditions is described in Appendix B. During the 1998-99 test season, a total of 842 tests were conducted on flat plates at the APS test site at Dorval Airport. All of the 842 tests occurred during natural precipitation. Of this total, 671 data points were usable. A breakdown of data points collected is listed below.

	# of Tests
Usable	671
Fluid not failed (e.g. snow stopped)	132
Different precipitation (ZR-, ZD, IP, ...)	10
Other (discontinued fluids)	30
Total tests conducted	842

The tests referred to as "different precipitation" above are tests carried out under natural freezing conditions other than snow and are described separately in Subsection 6.1.

The breakdown, by fluid type, of the 671 usable tests conducted in natural snow is shown in Figure 3.1 and summarized below.

Fluid Type	# of Tests
Type IV Neat	219
Type IV 75/25	176
Type IV 50/50	68
Type I (standard)	98
Type II Neat	36
Type II 75/25	32
Type II 50/50	19
Other	23
Total Usable Tests	**671**

Table 3.1 provides a summary of the Type IV tests that were conducted in natural snow conditions on a month-by-month basis. The largest quantity of tests were conducted in the month of March, due in part to the late receipt of fluids from certain manufacturers.

3.1.2 Test Location and Fluids Tested

The Type I, Type II and Type IV fluids tested at Dorval Airport were manufactured by Clariant, Inland, Kilfrost, Octagon, SPCA and Union Carbide. Figure 3.1 shows all the fluid brands and dilutions tested in natural snow conditions at Dorval Airport, including the number of tests conducted.

3.1.3 Distribution of Average Precipitation Rates

Precipitation at Dorval was measured using plate pans, and two automated gauges from Environment Canada (READAC and CR21X). The rates of precipitation used in this report were computed using the plate pan method. Environment Canada gauges were used as a backup and also for evaluation of weather snow data, described in a separate report, TP 13486E (6).

The distribution of the average precipitation rate for the tests is summarized in Figure 3.2 for Type IV fluids, Figure 3.3 for Type II fluids and Figure 3.4 for Type I fluids.

FIGURE 3.1

NUMBER OF NATURAL SNOW TESTS CONDUCTED

1998-99 TEST SEASON AT DORVAL

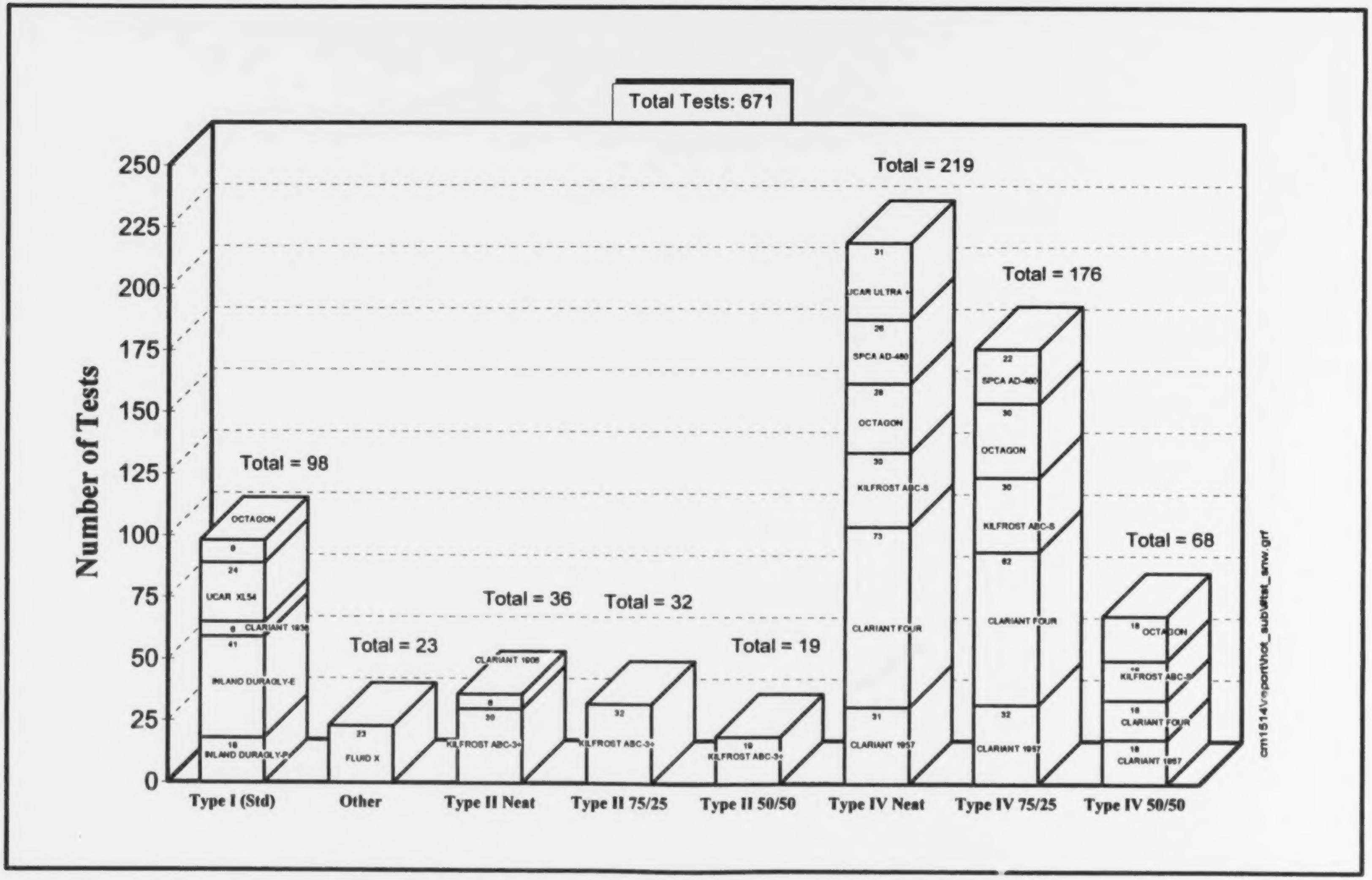


TABLE 3.1

Dorval Natural Snow Data

Type IV Fluids

December 1998

SUN	MON	TUES	WED	THURS	FRI	SAT
		1	2	3	4	5
6	7	8	9	10	11	12
13	14	15	16	17	18	19 4
20	21 7	22	23	24	25	26
27	28	29	30	31		

January 1999

SUN	MON	TUES	WED	THURS	FRI	SAT
					1	2
3 20	4	5	6 4	7	8 45	9 28
10	11	12 12	13	14 2	15 34	16
17	18	19	20	21	22	23
24	25	26	27	28	29	30
31						

February 1999

SUN	MON	TUES	WED	THURS	FRI	SAT
	1	2	3	4	5	6 18
7	8	9	10	11	12 10	13
14	15	16	17 4	18	19	20
21	22	23	24	25	26	27
28 24						

March 1999

SUN	MON	TUES	WED	THURS	FRI	SAT
	1	2 20	3 39	4 10	5	6 72
7	8	9	10	11 52	12 6	13
14	15	16	17	18	19	20
21 24	22 28	23	24	25	26	27
28	29	30	31			

Number of Tests Conducted in 1998-99 Season

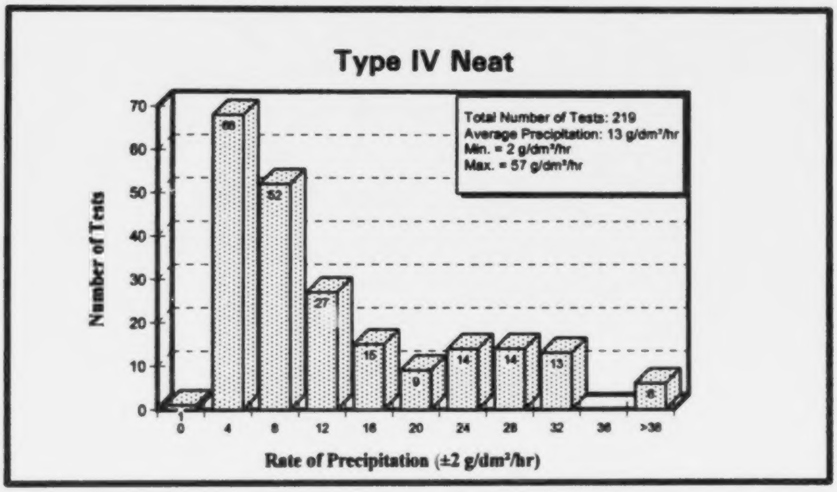
Type IV Fluids	Neat	75/25	50/50	Total
OCTAGON Max-flight	28	30	18	76
UCAR Ultra+	31			31
CLARIANT SAFEWING FOUR	73	62	16	151
ARIANT SAFEWING MPIV 1957	31	32	18	81
KILFROST ABC-S	30	30	16	76
SPCA AD-480	26	22	0	48
Total:	219	176	68	463

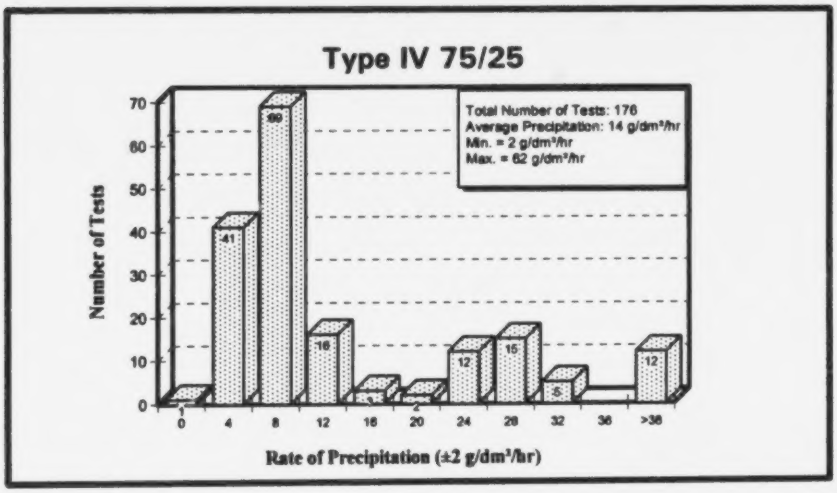
FIGURE 3.2

DISTRIBUTION OF PRECIPITATION RATE - TYPE IV FLUIDS

Natural Snow Tests

1998-99





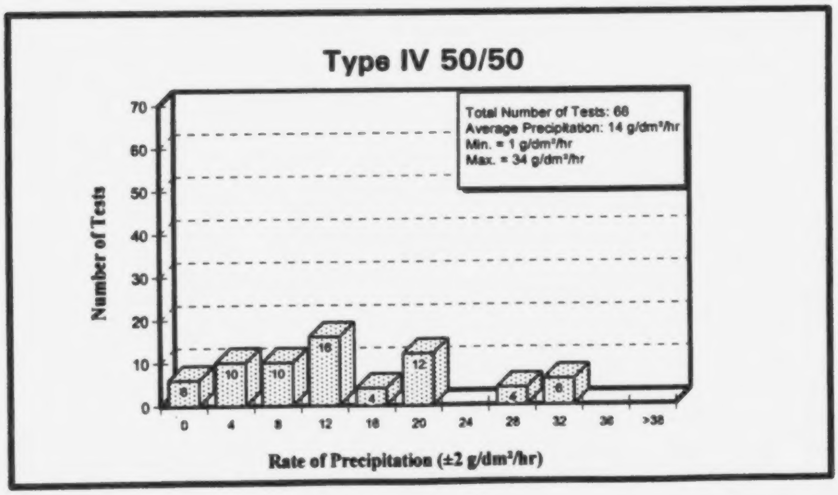


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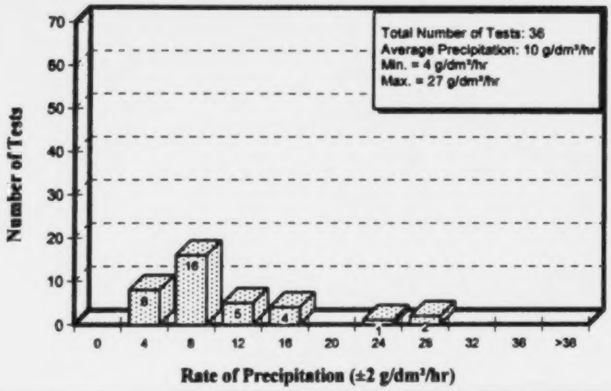
FIGURE 3.3

DISTRIBUTION OF PRECIPITATION RATE - TYPE II FLUIDS

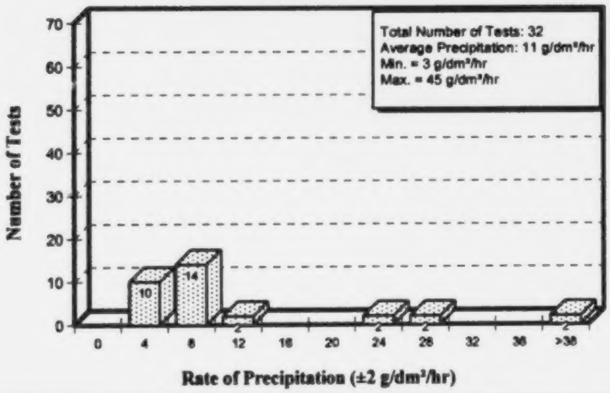
Natural Snow Tests

1998-99

Type II Neat



Type II 75/25



Type II 50/50

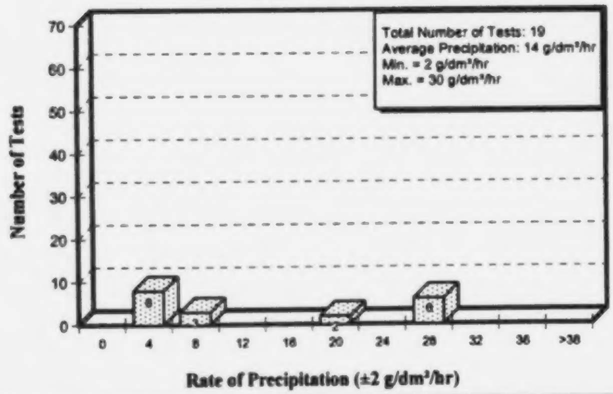


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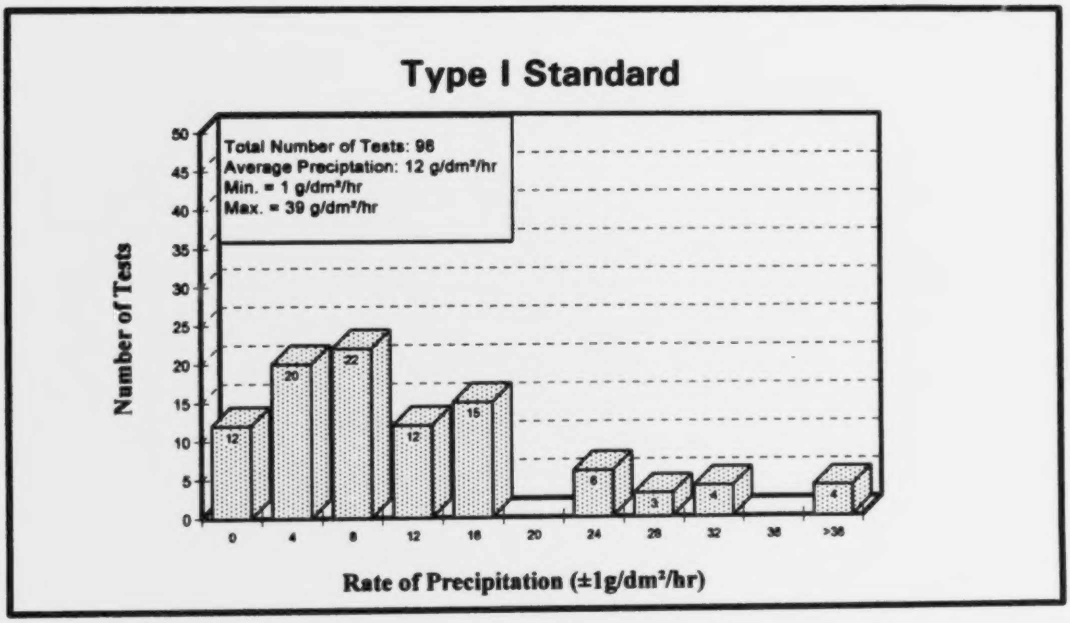
FIGURE 3.4

DISTRIBUTION OF PRECIPITATION RATE - STANDARD TYPE I FLUIDS

Natural Snow Tests, 1998-99



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3.1.4 Distribution of Other Meteorological Conditions

The air temperature and wind speed over the duration of the tests were obtained from Environment Canada's automated weather station (READAC). In previous years, these parameters were measured with instruments purchased by APS on behalf of Transport Canada. These instruments are still operational, and were used this year for weather monitoring purposes only.

A summary of the distribution of the READAC measurements for each Type IV fluid test is illustrated in Figures 3.3 to 3.5 as follows:

Figure 3.5	Distribution of Air Temperature for Type IV Fluids;
Figure 3.6	Distribution of Air Temperature for Type II Fluids;
Figure 3.7	Distribution of Air Temperature for Type I Fluids;
Figure 3.8	Distribution of Wind Speed for Type IV Fluids;
Figure 3.9	Distribution of Wind Speed for Type II Fluids; and
Figure 3.10	Distribution of Wind Speed for Type I Fluids.

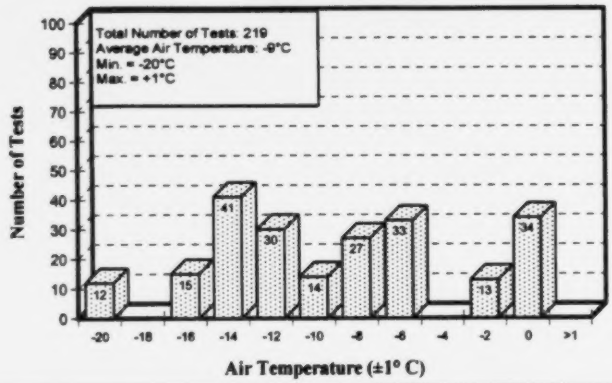
FIGURE 3.5

DISTRIBUTION OF AIR TEMPERATURE - TYPE IV FLUIDS

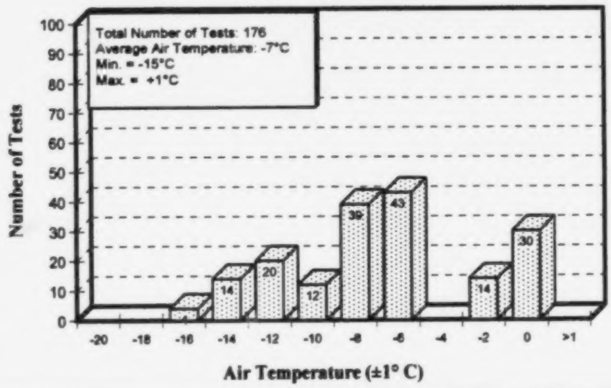
Natural Snow Tests

1998-99

Type IV Neat



Type IV 75/25



Type IV 50/50

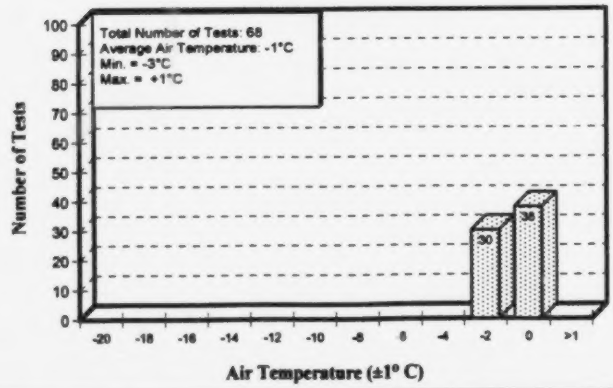


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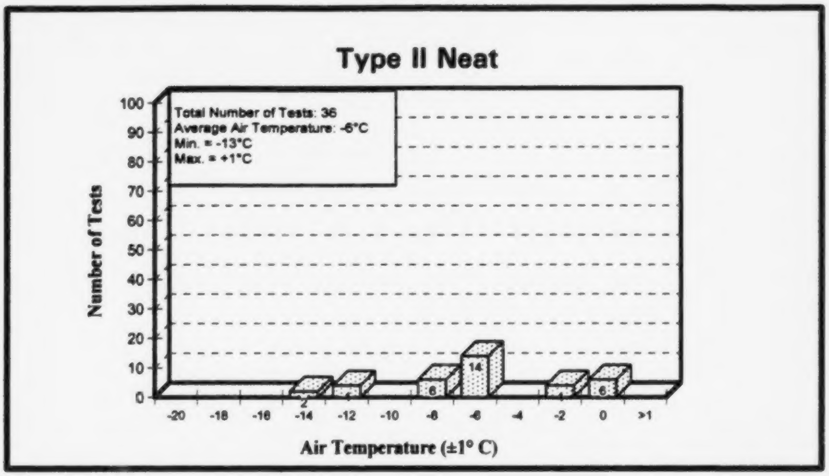
FIGURE 3.6

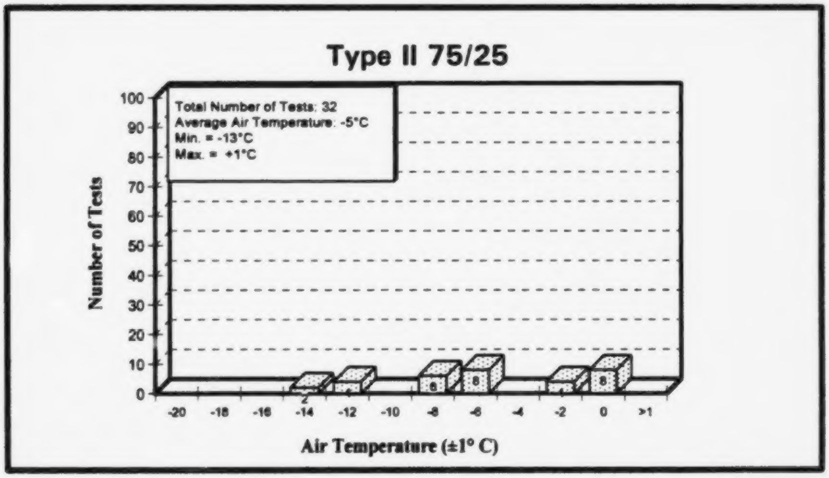
DISTRIBUTION OF AIR TEMPERATURE - TYPE II FLUIDS

Natural Snow Tests

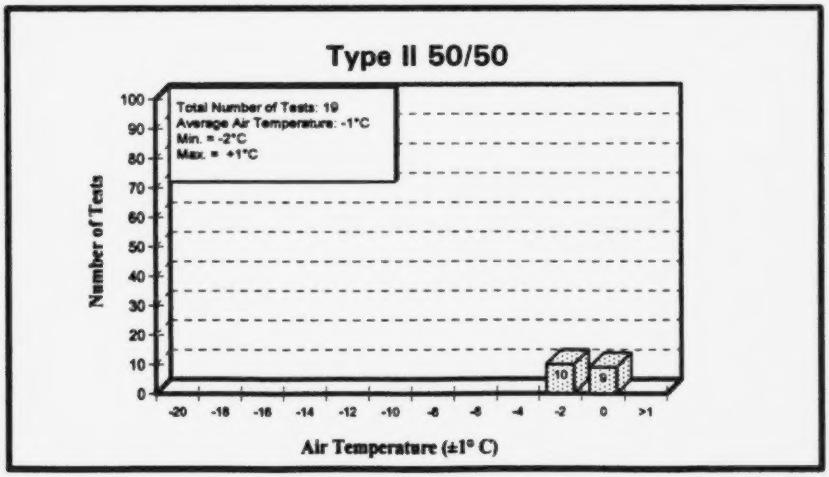
1998-99



Type II Neat



Type II 75/25



Type II 50/50

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FIGURE 3.7

DISTRIBUTION OF AIR TEMPERATURE - STANDARD TYPE I FLUIDS

Natural Snow Tests, 1998-99

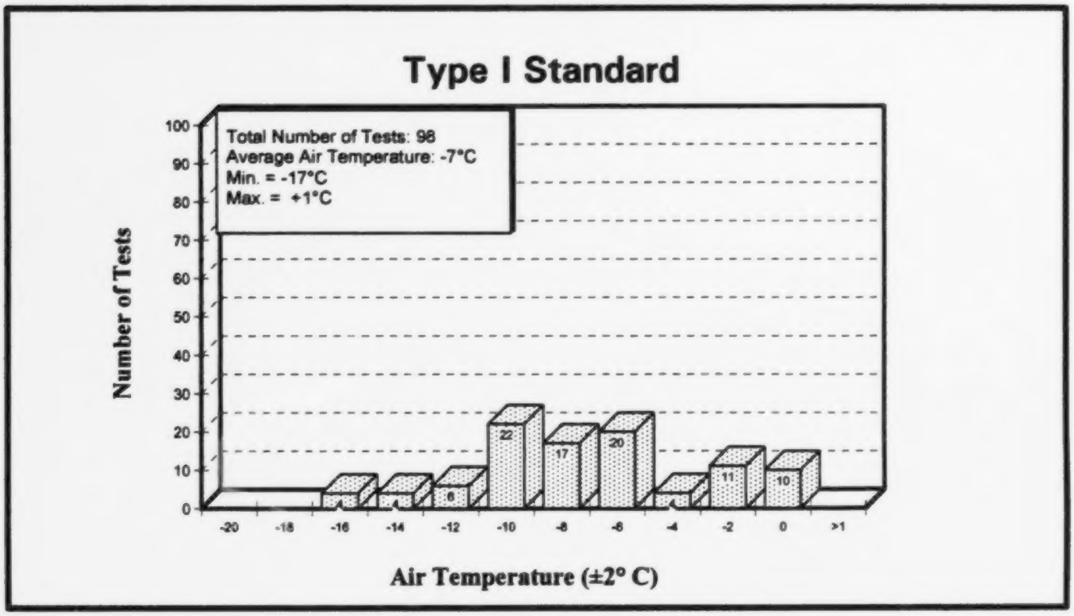

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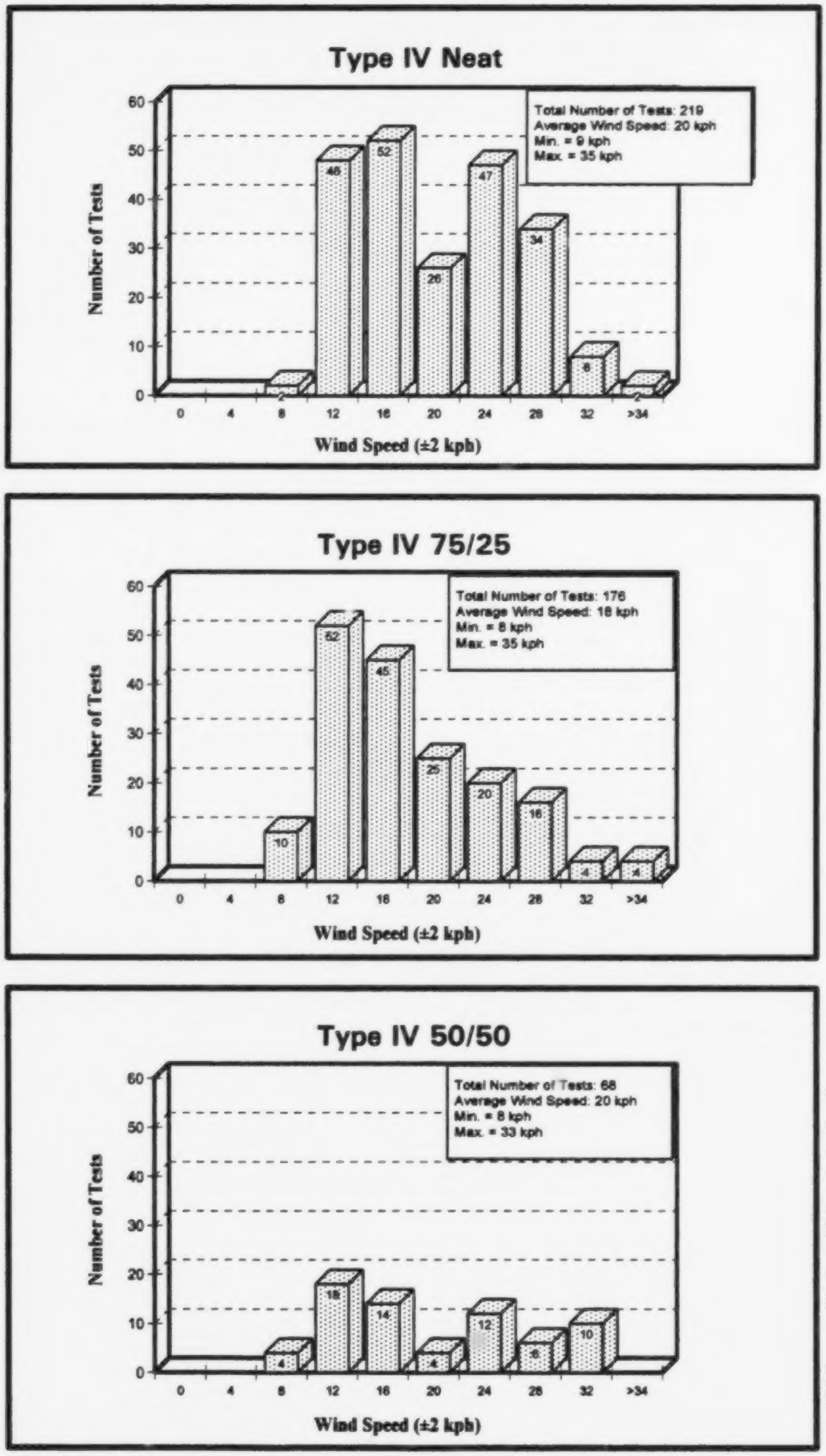
FIGURE 3.8

DISTRIBUTION OF WIND SPEED - TYPE IV FLUIDS

Natural Snow Tests

1998-99



cm1514\report\hot_sub\dwnd_sw4.grf

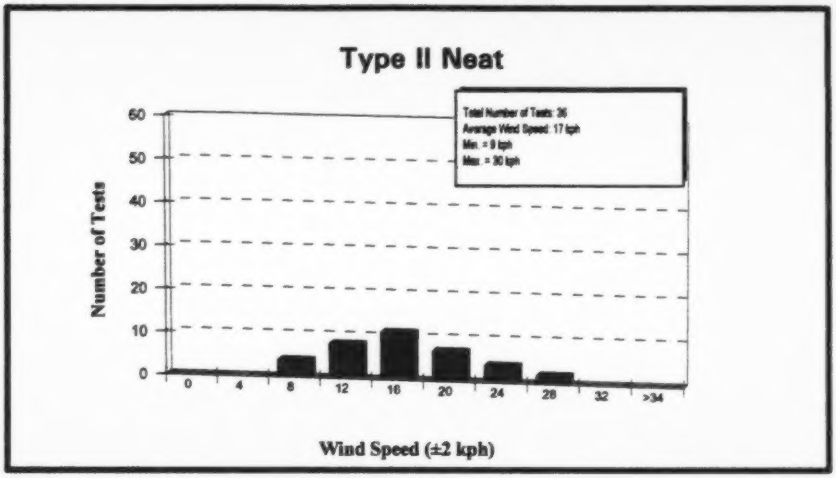
NB: Measured at 10 metre height.

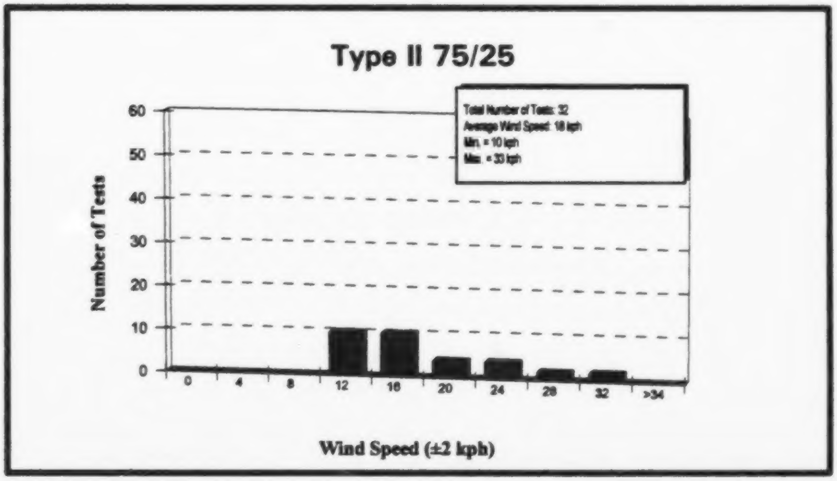
FIGURE 3.9

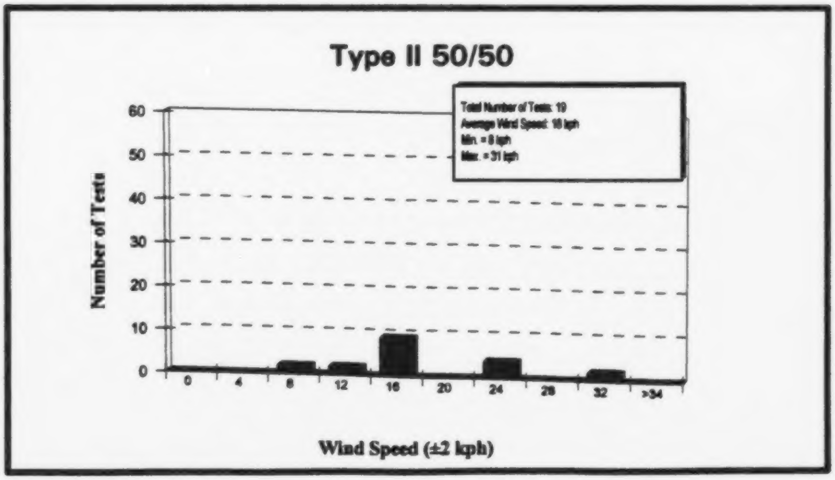
DISTRIBUTION OF WIND SPEED - TYPE II FLUIDS

Natural Snow Tests

1998-99


Type II Neat


Type II 75/25


Type II 50/50

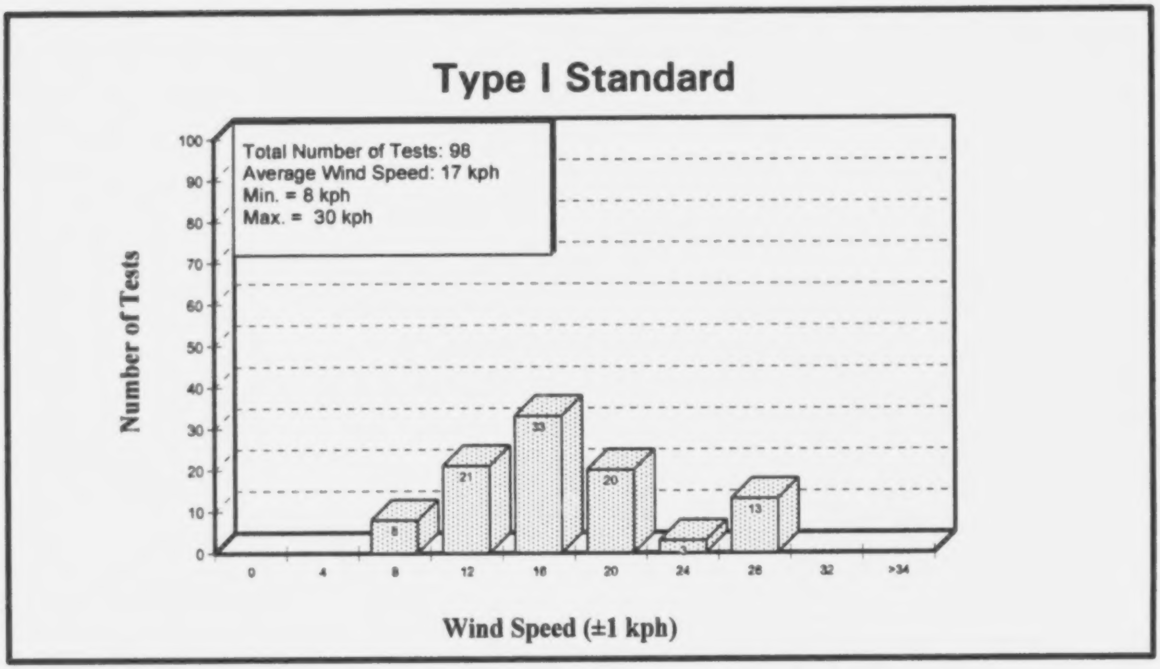
cm1514\report\hot_sub\dwnd_sw2.grf

NB: Measured at 10 metre height.

FIGURE 3.10

DISTRIBUTION OF WIND SPEED - STANDARD TYPE I FLUIDS

Natural Snow Tests, 1998-99



cm1514\report\hot_sub\dwnd_sw1.grf

NB: Measured at 10 metre height.

3.2 Freezing Drizzle and Light Freezing Rain Tests

3.2.1 Data Acquisition

The test plan developed for experiments to be conducted in freezing drizzle and light freezing rain is described in Appendix C. A total of 215 freezing drizzle and 189 light freezing rain tests were carried out in the 1998-99 winter, as shown in Figure 3.11.

3.2.2 Test Location and Fluids Tested

All 404 freezing precipitation tests were conducted at NRC's CEF in Ottawa. The fluids tested were supplied by Clariant, Kilfrost, Octagon, SPCA, Union Carbide, Jarchem, Home Oil, and Inland Technologies.

3.2.3 Distribution of Average Precipitation Rates

Tables 3.2 and 3.3 show the distribution of average precipitation rates recorded for fluid Types I, II and IV. As described in Section 2, the average precipitation rates for freezing drizzle and light freezing rain were computed from weight measurements taken with plate pans. The pans were positioned on the stand at every plate position before and after each run for a minimum of two 10-minute periods.

All fluids were tested at the upper and lower precipitation rate limits. The limits were 5 and 12.7 g/dm²/h for freezing drizzle, and 12.7 and 25 g/dm²/h for light freezing rain.

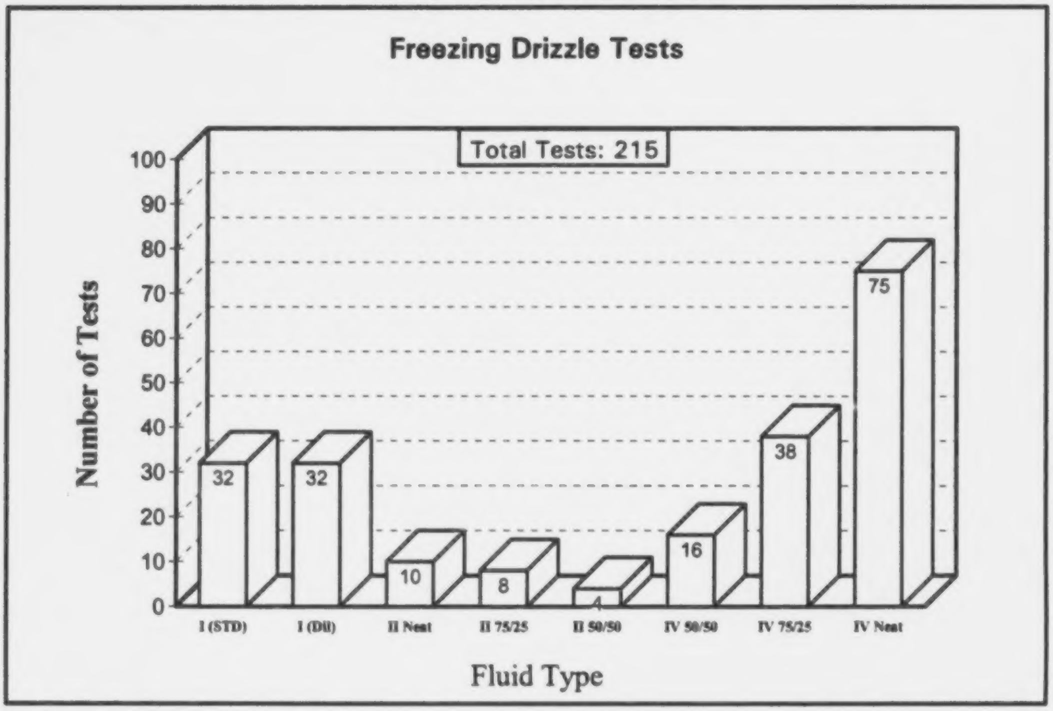
3.2.4 Distribution of Other Meteorological Conditions

Air temperature was the only other meteorological factor that varied during the freezing drizzle and light freezing rain tests. The distribution of air temperatures is also presented in Tables 3.2 and 3.3.

FIGURE 3.11

NUMBER OF SIMULATED FREEZING DRIZZLE AND LIGHT FREEZING RAIN TESTS

1998-99 TEST SEASON


Freezing Drizzle Tests

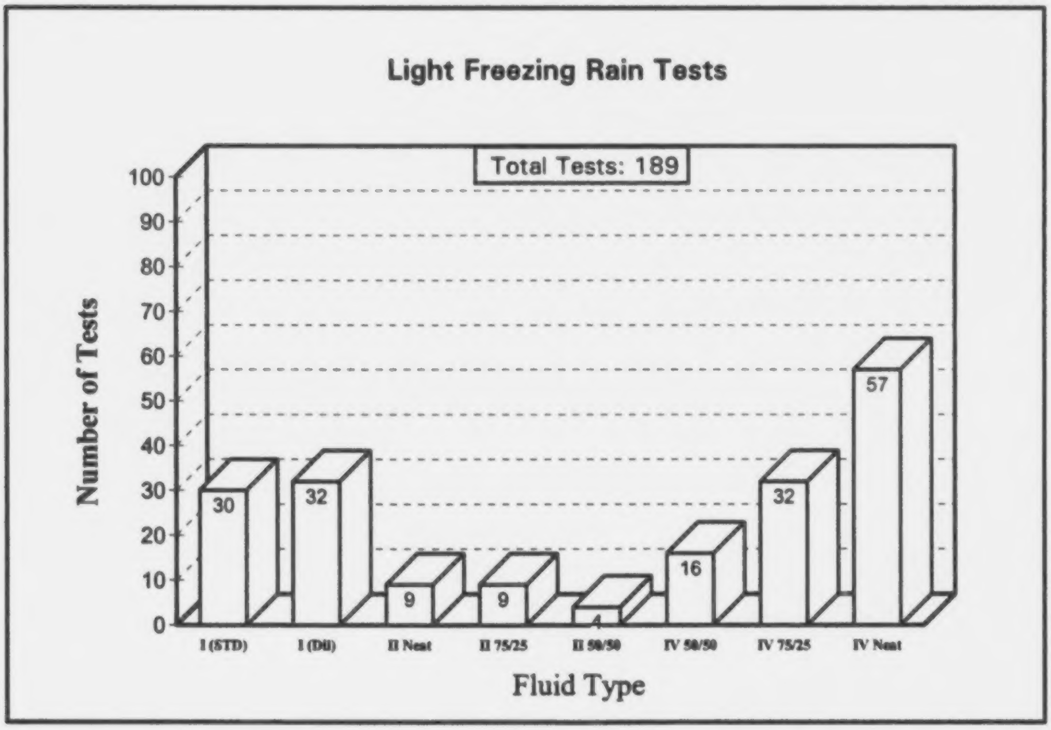

Light Freezing Rain Tests

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TABLE 3.2

DISTRIBUTION OF HOLDOVER TIME TESTS CONDUCTED BY TEMPERATURE AND PRECIPITATION RATE

SIMULATED FREEZING DRIZZLE/LIGHT FREEZING RAIN TESTS

1998-99

(# of Tests)

Type I Standard

	Freezing Drizzle		Freezing Rain	
	-3°C	-10°C	-3°C	-10°C
Low Rate	13	8	8	8
High Rate	8	4	8	6

Type I Diluted

	Freezing Drizzle	Freezing Rain
	-10°C	-10°C
Low Rate	16	16
High Rate	16	16

TABLE 3.3

DISTRIBUTION OF HOLDOVER TIME TESTS CONDUCTED BY TEMPERATURE AND PRECIPITATION RATE

SIMULATED FREEZING DRIZZLE/LIGHT FREEZING RAIN TESTS

1998-99

(# of Tests)

Type II

	ZD (-10°C)		ZD (-3°C)			ZR (-10°C)		ZR (-3°C)		
	Neat	75/25	Neat	75/25	50/50	Neat	75/25	Neat	75/25	50/50
Low Rate	2	2	2	2	2	2	3	2	2	2
High Rate	3	2	3	2	2	3	2	2	2	2

Type IV

	ZD (-10°C)		ZD (-3°C)			ZR (-10°C)		ZR (-3°C)		
	Neat	75/25	Neat	75/25	50/50	Neat	75/25	Neat	75/25	50/50
Low Rate	22	9	22	11	8	12	8	12	8	8
High Rate	13	8	18	10	8	16	8	17	8	8

3.3 Simulated Freezing Fog Tests

3.3.1 Data Acquisition

A total of 270 tests were conducted with Type IV fluids in freezing fog conditions. The breakdown of these tests is shown in Figure 3.12

3.3.2 Test Location and Fluids Tested

All 270 freezing fog tests were conducted at NRC's CEF in Ottawa. The fluids tested were supplied by Clariant, Kilfrost, Octagon, SPCA , Union Carbide, Jarchem, Home Oil and Inland Technologies.

3.3.3 Distribution of Average Precipitation Rates

Tables 3.4 and 3.5 show the distribution of average precipitation rates recorded for all holdover time tests. As described in Section 2, the average precipitation rates for freezing fog were computed from weight measurements taken with plate pans. The pans were positioned on the stand at every plate location before and after each run for two 10 to 15-minute periods. Holdover time tests were conducted at precipitation rates of 2 to 5 g/dm²/h.

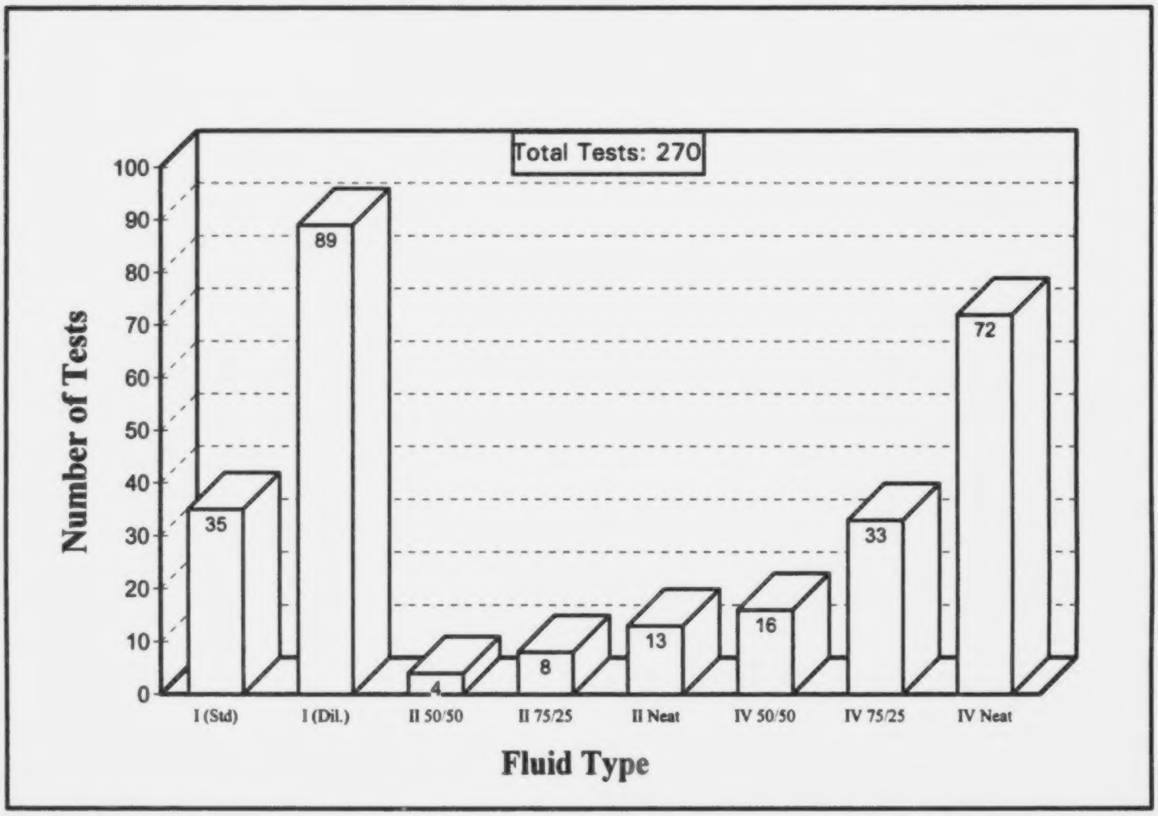
3.3.4 Distribution of Tests by Air Temperature

The other variable in freezing fog tests was temperature. The distributions of air temperatures for freezing fog tests are also presented in Tables 3.4 and 3.5.

FIGURE 3.12

NUMBER OF SIMULATED FREEZING FOG TESTS

1998-99 TEST SEASON



cm1514/report/hot_sub/#tst_fog.grf

TABLE 3.4

DISTRIBUTION OF HOLDOVER TIME TESTS CONDUCTED BY TEMPERATURE AND PRECIPITATION RATE

SIMULATED FREEZING FOG TESTS

1998-99

(# of Tests)

Type I Standard

	-3°C	-14°C	-25°C
Low Rate	6	6	5
High Rate	6	6	6

Type I Diluted

	-10°C	-30°C
Low Rate	16	16
High Rate	16	16

TABLE 3.5

DISTRIBUTION OF HOLDOVER TIME TESTS CONDUCTED BY TEMPERATURE AND PRECIPITATION RATE

SIMULATED FREEZING FOG TESTS

1998-99

(# of Tests)

Type II

	-3°C			-14°C		-25°C
	Neat	75/25	50/50	Neat	75/25	Neat
Low Rate	3	2	2	2	2	2
High Rate	2	2	2	2	2	2

Type IV

	-3°C			-14°C		-25°C
	Neat	75/25	50/50	Neat	75/25	Neat
Low Rate	12	8	8	12	8	12
High Rate	12	9	8	12	8	12

3.4 Simulated Rain on Cold-Soaked Surface Tests

3.4.1 Data Acquisition

A total of 94 cold-soak tests, using 7.5 cm deep sealed boxes, were conducted during the 1998-99 test season. The breakdown of tests is shown in Figure 3.13.

3.4.2 Test Location and Fluids Tested

All 94 tests were conducted at NRC's CEF in Ottawa. The fluids tested were supplied by Clariant, Kilfrost, Octagon, SPCA, Union Carbide, Jarchem, Home Oil, and Inland Technologies.

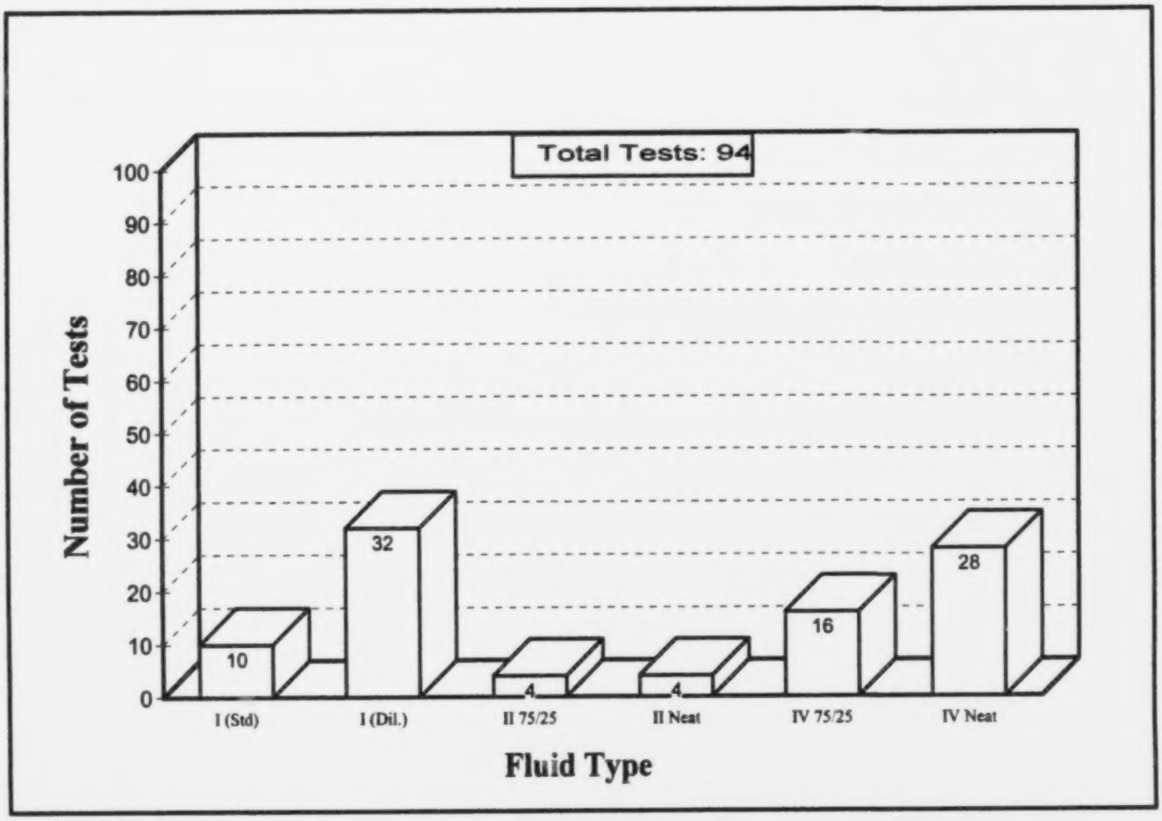
3.4.3 Distribution of Average Precipitation Rates

Table 3.6 shows the distribution of precipitation intensity. The average precipitation rate was measured using plate pans. The precipitation for drizzle was produced using the same apparatus as was used for freezing drizzle. Moderate rain was also produced using the same apparatus, but with different hypodermic needles and water/air pressures.

FIGURE 3.13

NUMBER OF COLD-SOAK BOX TESTS

1998-99 TEST SEASON



cm1514/report/hot_sub/#tst_cs.grf

TABLE 3.6

DISTRIBUTION OF HOLDOVER TIME TESTS CONDUCTED BY TEMPERATURE AND PRECIPITATION RATE

COLD-SOAK BOX TESTS

1998-99

(# of Tests)

Type I

	Standard	Diluted
Low Rate	6	16
High Rate	4	16

Type II

	Neat	75/25
Low Rate	2	2
High Rate	2	2

Type IV

	Neat	75/25
Low Rate	11	8
High Rate	17	8

cm1514/report/hot_subs/Tables 3.2-3.6
At: CS Type I

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4. FLUID THICKNESS TESTS ON FLAT PLATES

Type II and Type IV fluid thickness tests on flat plates were conducted at NRC's CEF on one occasion during the 1998-99 test season. The purpose of these tests was to measure film thickness profiles of new fluids and to investigate the effect of poured fluid quantity.

The listing of tests conducted is displayed below in Table 4.1 and summarized in Table 4.2:

Table 4.1 Fluid Thickness Tests Conducted

Fluid	# of Tests
Non-Sheared Neat	8
Neat	22
75/25	8
50/50	8

In addition, four thickness tests were conducted with Type I recycled fluids and two tests were conducted with a reference fluid formulation, Fluid X.

4.1 General Procedures and Stabilized Neat Fluid Profiles

Each fluid was poured onto a flat plate mounted on a test stand inclined at 10° to the horizontal. Wet film thickness measurements of the poured fluid were taken at the 15 cm (6 in.) line at pre-selected time intervals spanning 30 minutes.

The fluid thickness decreases rapidly after the fluid is poured, but the process slows once excess fluid sheds from the plate. A complete description of the film thickness test procedure is reported in the 1996-97 Transport Canada report TP 12900E (9). In 1998-99 testing at NRC, fluid thickness tests were conducted at ambient temperatures between -3°C and -5°C.

Figure 4.1 illustrates the thickness decay at the 15 cm line of Type IV neat fluids tested during winter 1995-96. The results revealed that the Type IV fluids tested exhibited equivalent thickness profiles, and that fluid thickness started to stabilize after 10 minutes from the start of the test.

Figure 4.2 shows thickness decay curves for fluids tested in the 1996-97 winter season. A comparison of thickness decay of Type IV fluids tested during winter 1996-97 shows that the thickness measurements of these neat Type IV fluids were significantly different from the 1995-96 Type IV fluids and different from one another; Ultra+ and Kilfrost were more than twice the thickness of Octagon and Hoechst MPIV 1957, after 30 minutes.

TABLE 4.2

LOG OF FLUID THICKNESS TESTS - NRC OTTAWA

Test #	Form #	Total Elapsed Time (min)	Test Date	Fluid Name	Fluid Concent.	Fluid Quantities (Litres)	Ambient Air Temp. (AAT, °C)	Fluid Temp. (°C)	Stabilized Thickness after 30 min. at 6" Line (mils)	Corrected Thickness (mils)	Corrected Thickness (mm)
9	2	30	29-Mar-99	CLARIANT SAFEWING MP IV 1957	Neat (NS)	1	-4.5	-4.5	30	33	0.83
10	2	30	29-Mar-99	CLARIANT SAFEWING MP IV 1957	Neat (NS)	1	-4.5	-4.5	30	33	0.83
11	2	30	29-Mar-99	CLARIANT SAFEWING MP IV 1957	Neat	1	-4.5	-4.5	25	28	0.70
12	2	30	29-Mar-99	CLARIANT SAFEWING MP IV 1957	Neat	1	-4.5	-4.5	25	28	0.70
13	3	30	29-Mar-99	CLARIANT SAFEWING MP IV 1957	75%	1	-4.5	-4.5	35	38	0.95
14	3	30	29-Mar-99	CLARIANT SAFEWING MP IV 1957	75%	1	-4.5	-4.5	35	38	0.95
15	3	30	29-Mar-99	CLARIANT SAFEWING MP IV 1957	50%	1	-4.5	-4.5	12	13	0.33
16	3	30	29-Mar-99	CLARIANT SAFEWING MP IV 1957	50%	1	-4.5	-4.5	14	15	0.38
17	3	30	29-Mar-99	KILFROST ABC-II PLUS	Neat (NS)	1	-4.5	-4.5	20	23	0.58
18	3	30	29-Mar-99	KILFROST ABC-II PLUS	Neat (NS)	1	-4.5	-4.5	20	23	0.58
19	10	30	30-Mar-99	KILFROST ABC-II PLUS	Neat	1	-4.8	-4.8	11	12	0.29
20	10	29	30-Mar-99	KILFROST ABC-II PLUS	Neat	1	-4.8	-4.8	10	11	0.27
21	4	30	29-Mar-99	KILFROST ABC-II PLUS	75%	1	-4.5	-4.5	30	32	0.82
22	6	30	29-Mar-99	KILFROST ABC-II PLUS	75%	1	-4.5	-4.5	30	33	0.83
23	10	30	30-Mar-99	KILFROST ABC-II PLUS	50%	1	-4.8	-4.8	18	19	0.48
24	10	30	30-Mar-99	KILFROST ABC-II PLUS	50%	1	-4.8	-4.8	18	18	0.46
25	4	29	29-Mar-99	KILFROST ABC-S	Neat (NS)	1	-4.5	-4.5	64	72	1.83
26	8	29	29-Mar-99	KILFROST ABC-S	Neat (NS)	1	-4.5	-4.5	64	72	1.83
27	10	30	30-Mar-99	KILFROST ABC-S	Neat	1	-4.8	-4.8	55	58	1.46
28	11	30	30-Mar-99	KILFROST ABC-S	Neat	1	-4.7	-4.7	60	63	1.59
29	4	29	29-Mar-99	KILFROST ABC-S	75%	1	-4.5	-4.5	40	43	1.08
30	7	30	29-Mar-99	KILFROST ABC-S	75%	1	-4.5	-4.5	40	43	1.08
31	5	30	29-Mar-99	KILFROST ABC-S	50%	1	-4.5	-4.5	12	13	0.32
32	7	30	29-Mar-99	KILFROST ABC-S	50%	1	-4.5	-4.5	12	13	0.32
33	5	30	29-Mar-99	OCTAGON MAX-FLIGHT	Neat	1	-4.5	-4.5	35	38	0.95
34	7	30	29-Mar-99	OCTAGON MAX-FLIGHT	Neat	1	-4.5	-4.5	30	33	0.83
35	5	29	29-Mar-99	OCTAGON MAX-FLIGHT	75%	1	-4.5	-4.5	30	33	0.83
36	7	30	29-Mar-99	OCTAGON MAX-FLIGHT	75%	1	-4.5	-4.5	35	38	0.95
37	5	30	29-Mar-99	OCTAGON MAX-FLIGHT	50%	1	-4.5	-4.5	12	13	0.32
38	8	30	29-Mar-99	OCTAGON MAX-FLIGHT	50%	1	-4.5	-4.5	12	13	0.32
39	10	30	30-Mar-99	OCTAGON MAX-FLIGHT	Neat (NS)	1	-4.8	-4.8	50	53	1.33
40	10	30	30-Mar-99	OCTAGON MAX-FLIGHT	Neat (NS)	1	-4.7	-4.7	45	48	1.21
41	5	29	29-Mar-99	UCAR ULTRA +	Neat	1	-4.5	-4.5	30	33	0.83
42	8	30	29-Mar-99	UCAR ULTRA +	Neat	1	-4.5	-4.5	35	38	0.95
43	6	30	29-Mar-99	INLAND DURAGLY-E	Std	1	-4.5	20	1.5	2	0.05

TABLE 4.2 cont.

LOG OF FLUID THICKNESS TESTS - NRC OTTAWA

Test #	Form #	Total Elapsed Time (min)	Test Date	Fluid Name	Fluid Concent.	Fluid Quantities (Litres)	Ambient Air Temp. (AAT, °C)	Fluid Temp. (°C)	Stabilized Thickness after 30 min. at 6" Line (mils)	Corrected Thickness (mils)	Corrected Thickness (mm)
44	8	30	29-Mar-99	INLAND DURAGLY-E	Std	1	-4.5	20	1.5	2	0.05
45	6	29	29-Mar-99	INLAND DURAGLY-P	Std	1	-4.5	20	2.6	3	0.07
46	8	30	29-Mar-99	INLAND DURAGLY-P	Std	1	-4.5	20	2.6	3	0.07
47	6	30	29-Mar-99	FLUID X	Std	1	-4.5	-4.5	45	48	1.21
48	9	30	29-Mar-99	FLUID X	Std	1	-4.5	-4.5	40	43	1.08
Fluid Quantity Thickness Trials											
A	12	30	30-Mar-99	UCAR ULTRA +	Neat	0.1	-4.5	-4.5	22	23	0.58
B	12	30	30-Mar-99	UCAR ULTRA +	Neat	0.5	-4.5	-4.5	35	37.5	0.95
C	12	29	30-Mar-99	UCAR ULTRA +	Neat	1	-4.5	-4.5	35	37.5	0.95
D	12	30	30-Mar-99	UCAR ULTRA +	Neat	0.25	-4.5	-4.5	35	37.5	0.95
E	12	30	30-Mar-99	UCAR ULTRA +	Neat	2	-4.3	-4.3	35	37.5	0.95
F	12	37	30-Mar-99	UCAR ULTRA +	Neat	4	-4.3	-4.3	35	37.5	0.95
G	13	29	1-Apr-99	CLARIANT SAFEWING MP IV 1957	Neat	0.1	-4.6	-4.6	22	23	0.58
H	13	31	1-Apr-99	CLARIANT SAFEWING MP IV 1957	Neat	0.25	-4.6	-4.6	22	23	0.58
I	13	29	1-Apr-99	CLARIANT SAFEWING MP IV 1957	Neat	0.5	-4.6	-4.6	22	23	0.58
J	13	29	1-Apr-99	CLARIANT SAFEWING MP IV 1957	Neat	1	-4.6	-4.6	22	23	0.58
K	13	30	1-Apr-99	CLARIANT SAFEWING MP IV 1957	Neat	2	-4.6	-4.6	22	23	0.58
L	13	30	1-Apr-99	CLARIANT SAFEWING MP IV 1957	Neat	4	-4.6	-4.6	22	23	0.58

FIGURE 4.1

THICKNESS DECAY OF TYPE IV NEAT FLUIDS TESTED IN 1995-96

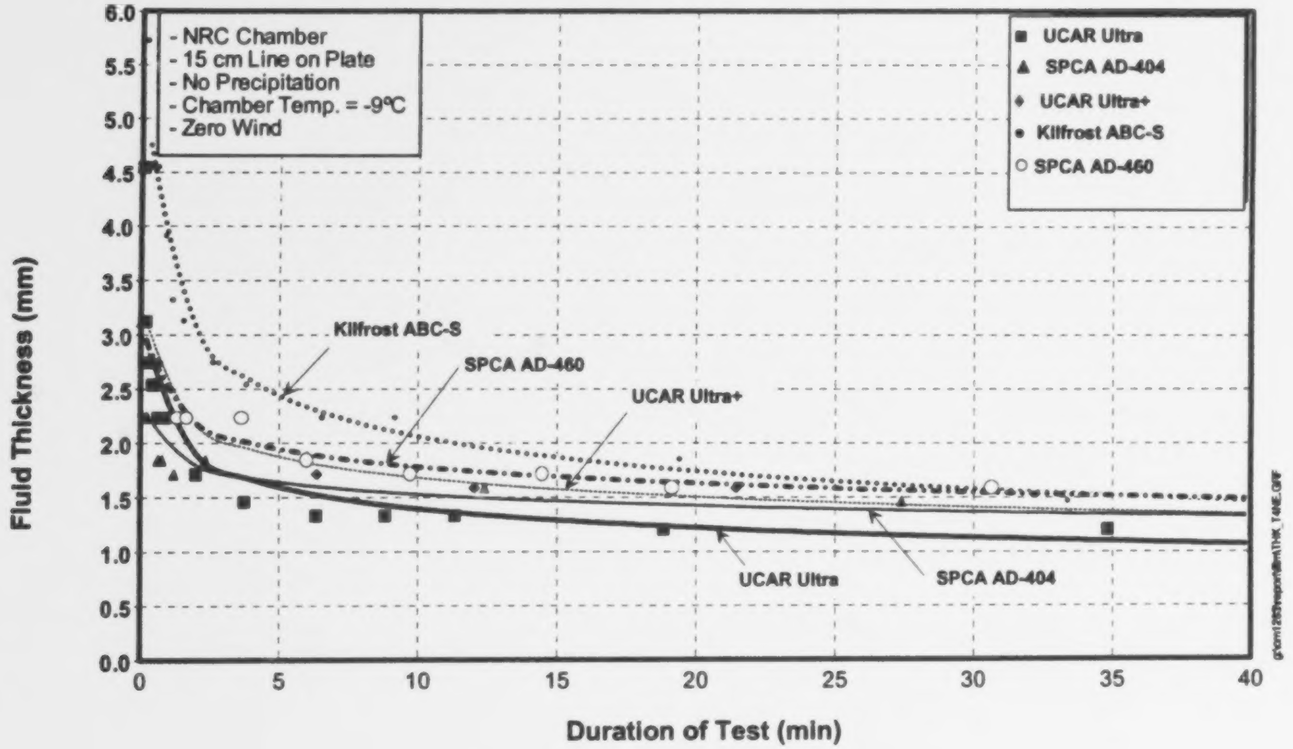


FIGURE 4.2

THICKNESS DECAY OF TYPE IV NEAT FLUIDS TESTED IN 1996-97

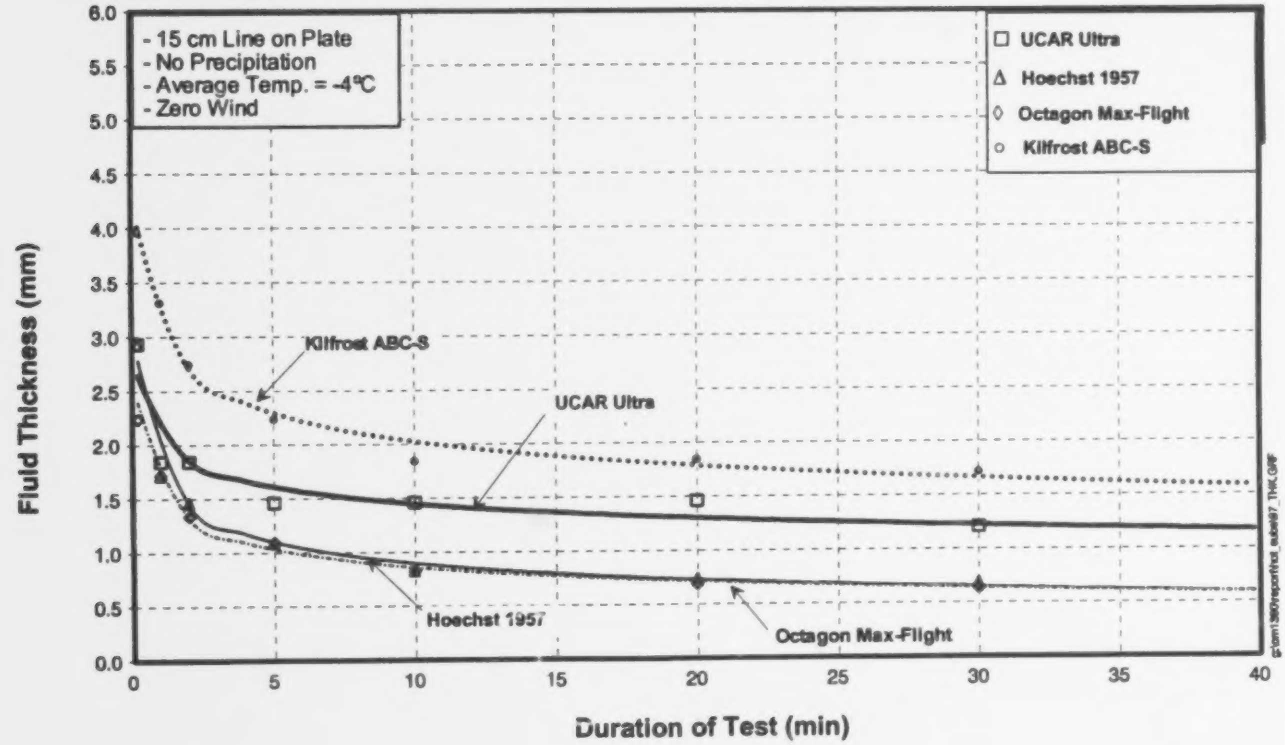


Figure 4.3 shows thickness decay curves for fluids tested in the 1997-98 winter season. Most of the fluids tested follow the same thickness profile as previous years' tests. UCAR Ultra IV and UCAR PG AAF, which did not satisfy the SAE specifications, were almost twice the thickness of SPCA AD-404 and Clariant MPIV 2001, and almost four times the thickness of Octagon Max-Flight and SPCA AD-480.

Figure 4.4 shows thickness decay curves for the fluids tested during the 1998-99 winter season. Most of the fluids tested tended to follow the same general thickness decay profiles as those recorded during the previous two years. However, the stabilized thickness values for the majority of the fluids differed from the values obtained during the previous years.

After 30 minutes, the stabilized film of the neat Octagon Max-Flight was significantly thicker than last year. The stabilized film of the neat Clariant 1957 fluid was thinner than that measured in 1997-98 tests. The stabilized thickness of UCAR Ultra+ was approximately half of that of 1996-97 tests with the same fluid. Kilfrost ABC-S remained the thickest fluid tested, with a stabilized film of approximately 1.5 mm.

Figure 4.5 shows four bar graphs, each one corresponding to a specific 1998-99 fluid brand. Each bar gives the fluid thickness at the 15 cm line of a trial, 30 minutes after fluid application. The number of tests used to produce each of the four graphs is indicated in the small box at the top centre of each graph. Two tests were performed for each standard dilution (Neat Non-Sheared, Neat, 75/25, and 50/50).

FIGURE 4.3

THICKNESS DECAY OF TYPE IV NEAT FLUIDS TESTED IN 1997-98

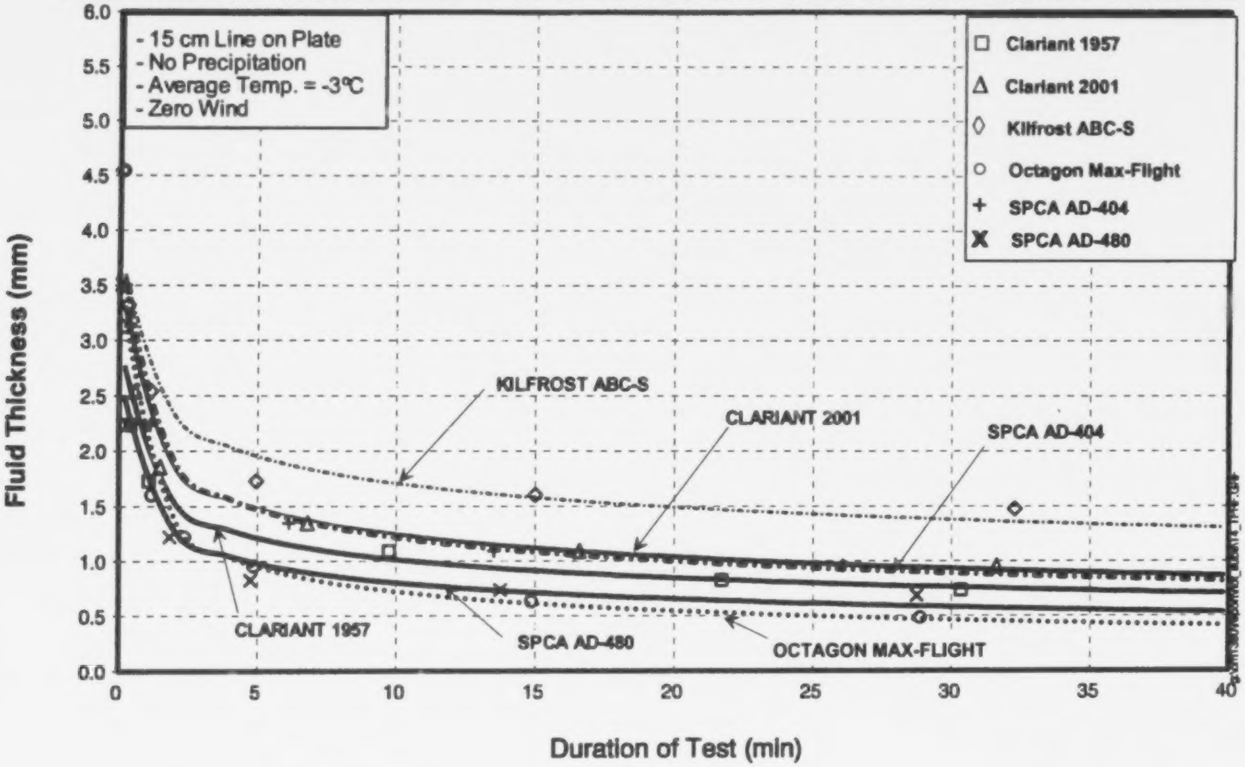


FIGURE 4.4

THICKNESS DECAY OF TYPE IV NEAT FLUIDS TESTED IN 1998-99

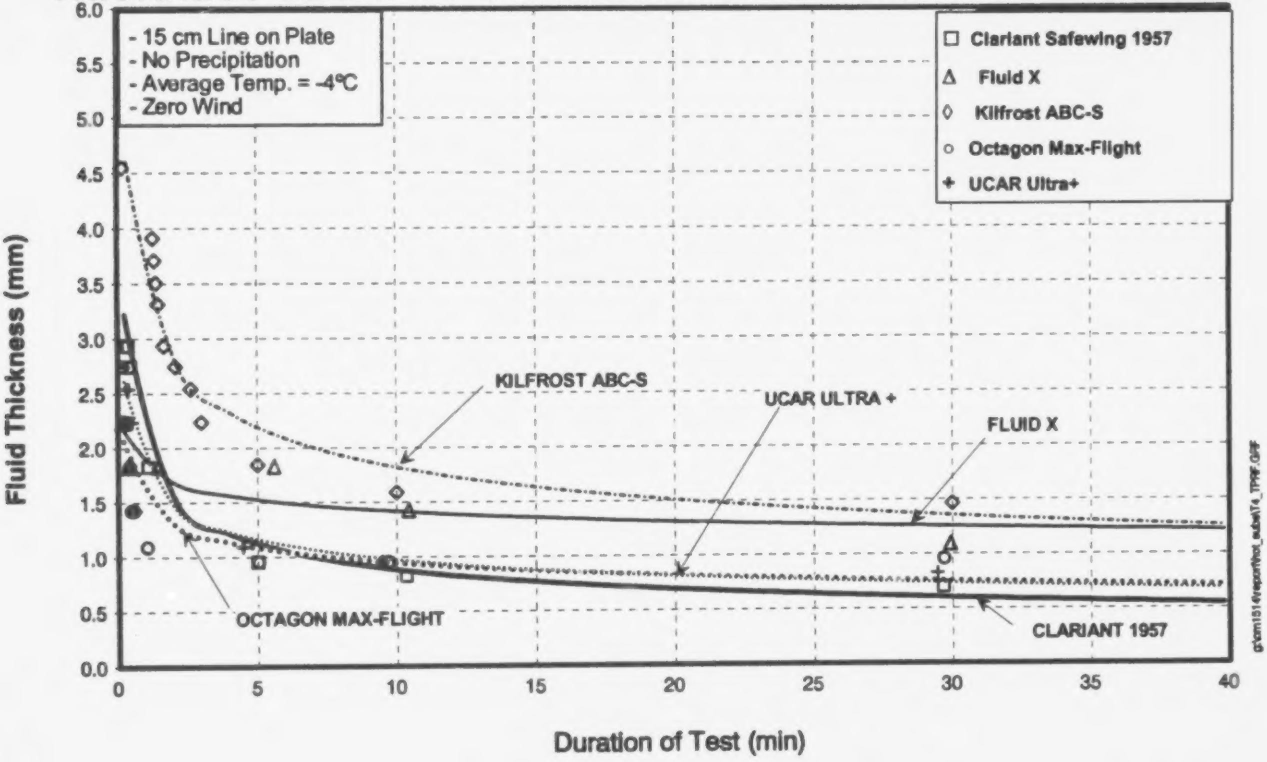
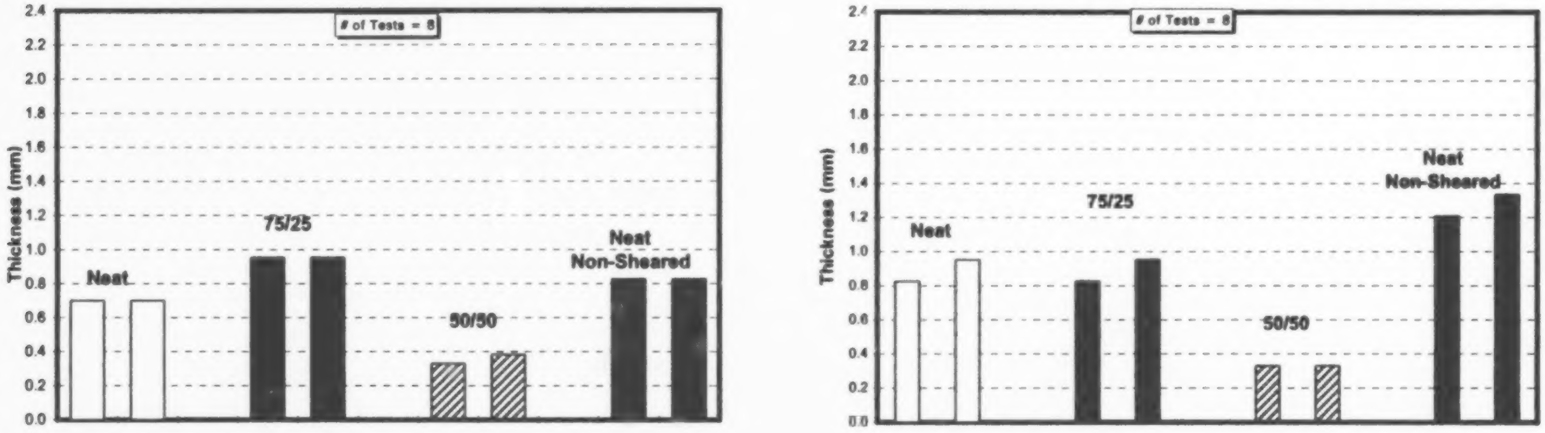


FIGURE 4.5

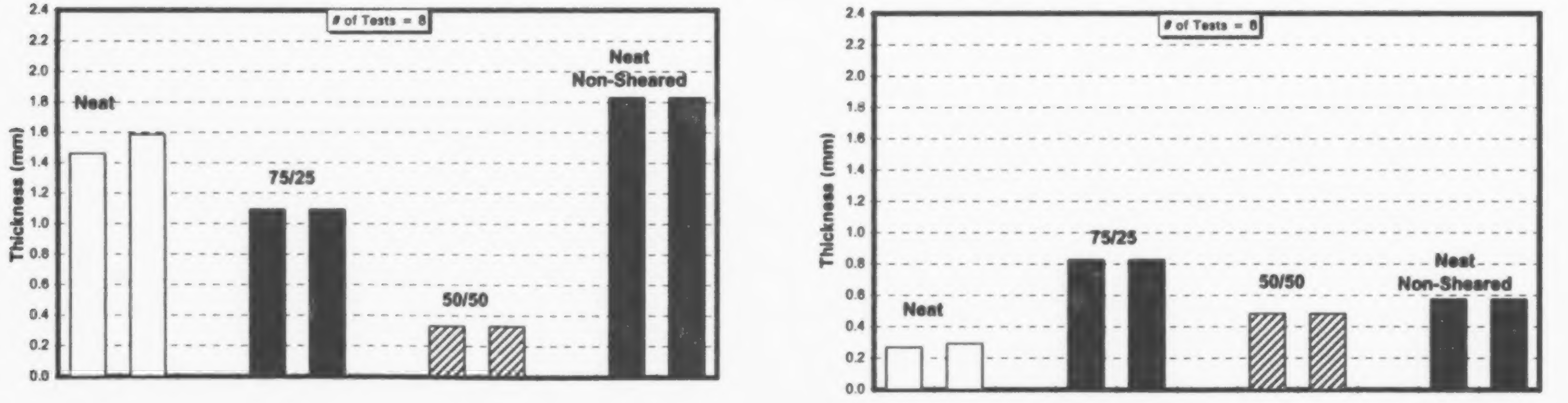
STABILIZED FILM THICKNESS OF 1998-99 FLUIDS AT 15 CM LINE

OAT = -3 to -5°C, Each bar represents a test

CLARIANT SAFEWING 1957, TYPE IV **OCTAGON MAX-FLIGHT, TYPE IV**



KILFROST ABC-S, TYPE IV **KILFROST ABC II PLUS, TYPE II**



4.2 Dilution Effect

The following is a point-form summary of some observations from Figure 4.5.

- Clariant MPIV 1957 fluid showed a 35 percent thickness increase in diluted 75/25 form, but the 50/50 formulation showed a significant decrease as compared to the sheared neat fluid. The non-sheared formulation stabilized at a thickness inferior to the 75/25 formulation but superior to the neat sheared fluid;

- Kilfrost ABC-S 75/25 showed a 28 percent decrease in thickness relative to the neat sheared fluid. The thickness of the 50/50 mix decreased to between 20 and 25 percent of the neat sheared fluid thickness. The non-sheared neat fluid thickness stabilized to a slightly greater value than did the sheared neat fluid;

- Kilfrost ABC-II Plus demonstrated an increase in thickness for the two dilutions tested. The 75/25 formulation was three times the thickness of the neat sheared fluid and the 50/50 had a stabilized thickness 75 percent greater than the sheared neat fluid. The non-sheared fluid thickness was twice that of the sheared neat fluid; and

- Octagon MaxFlight Type IV fluid thickness increased slightly when diluted to 75/25 but decreased significantly in the 50/50 formulation. The non-sheared neat fluid thickness was only slightly greater than the neat sheared fluid and the 75/25 formulation.

4.3 Influence of Applied Fluid Volume on Stabilized Thickness

The amount of fluid poured for each thickness test was changed from 1.5 L in past years to 1 L for the thickness tests performed during the 1998-99 test season. In order to validate this change in methodology, tests were run with different amounts of fluid, and the thickness versus time curves were then compared.

The fluid thickness profiles, shown in Figure 4.6, remain the same for all quantities of fluid poured, over and including 0.5 L. At the beginning of the tests performed with 0.1 and 0.25 L of fluid, the plate was not completely covered by the fluid. At the 30 minutes time interval, the 0.25 L test plates were completely covered, but the fluid was not completely covering the plates when 0.1 L were initially poured.

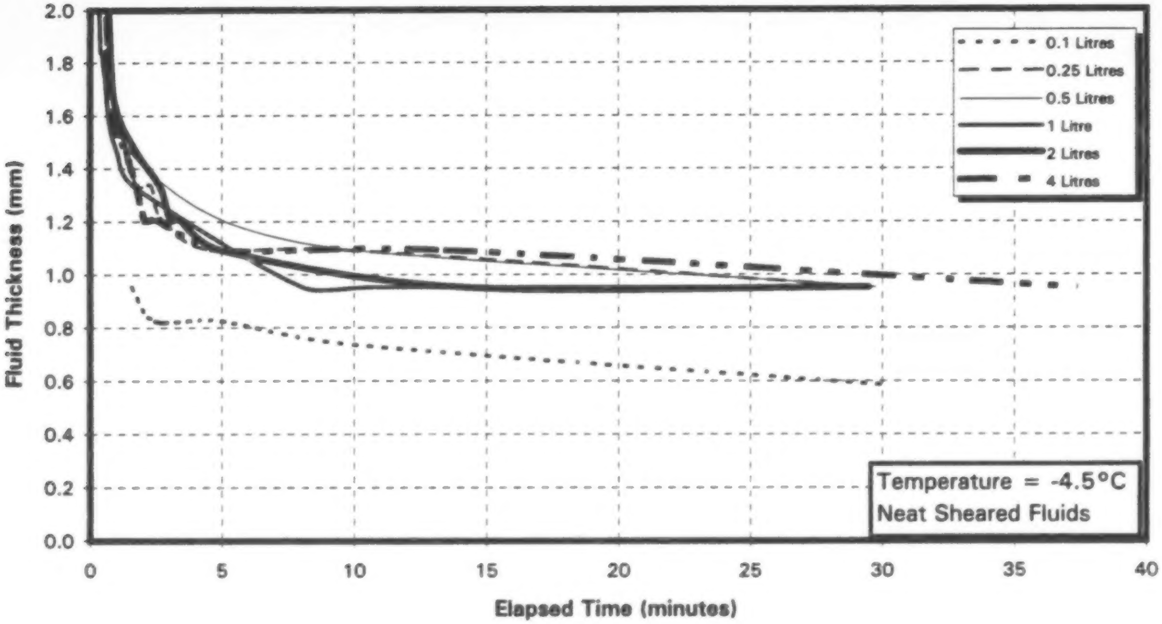
A further increase in the poured quantity of fluid does not change the stabilized fluid thickness since the excess fluid drains off the plate. The results obtained by pouring 1 L of fluid can be compared with the results from past years tests, where 1.5 L of fluid were poured. The stabilized fluid layer was prepared in both cases using an initial volume of fluid well in excess of the stabilized wet film volume.

Outdoor fluid thickness tests were performed in March 1995. These tests, documented in Transport Canada report TP 12654E (10), were conducted with the general objective of determining whether stabilized fluid thickness is affected by the amount of fluid poured. The stabilized thicknesses at the 15 cm line were found to be similar for fluid volumes of 1, 2, and 4 L. These findings are consistent with the results of 1998-99 tests.

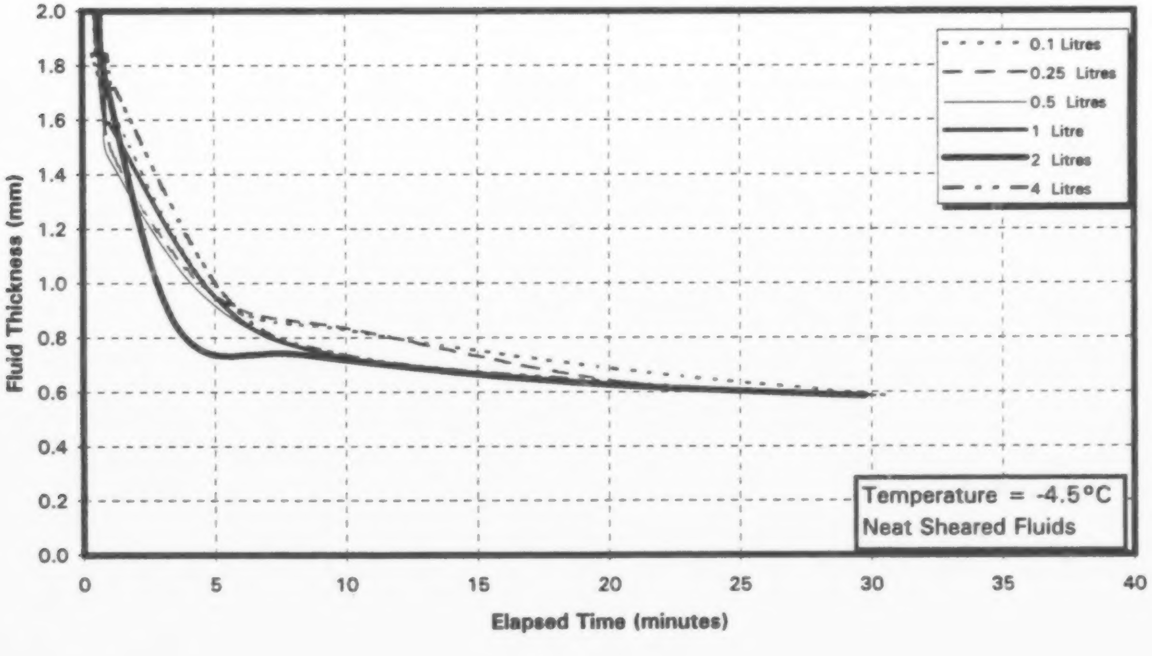
FIGURE 4.6

Thickness Profiles for Varying Quantities of Type IV Fluids

Fluid Quantity vs. Thickness for UCAR Ultra +



Fluid Quantity vs. Thickness for Clariant Safewing 1957



4.4 Year-to-Year Fluid Differences

The stabilized fluid thickness is fluid dependent for each of the Type IV fluids tested. The measured stabilized thickness has also varied over the last four years for each specific fluid. Figure 4.7 shows the progression of three different fluids. Kilfrost ABC-S has a stabilized thickness value and the measured results remain reasonably consistent from year to year. The samples tested in 1996-97 and 1997-98 were mid-range viscosity fluids comparable to the non-sheared tested in 1998-99. This year's neat sheared sample was thinner than the previous year's sheared samples. The stabilized thickness of the 75/25 formulation was in the same range for both the 1997-98 and 1998-99 tests. All tests performed with the 50/50 mix were in the same thickness range.

UCAR Ultra + shows a distinct progression from 1.46 mm in 1995-96 to 0.8 mm in 1998-99. The fluid formulation may have been changed between the 1995-96 and the 1996-97 seasons. The significant change in thickness between the 1996-97 fluid and the 1998-99 fluid is due to the lower viscosity of the sample tested in 1998-99.

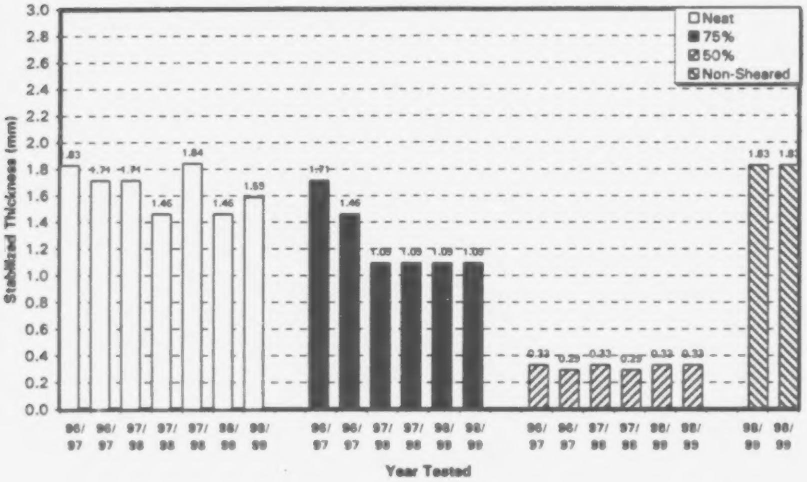
The Octagon MaxFlight fluid's stabilized wet film thickness is nearly double the value reported from the 1997-98 test season. The fluid tested in 1997-98 was a mid-viscosity fluid and the fluid tested in 1998-99 was a low viscosity fluid. The change in fluid thickness observed in Octagon MaxFlight is not understood.

FIGURE 4.7

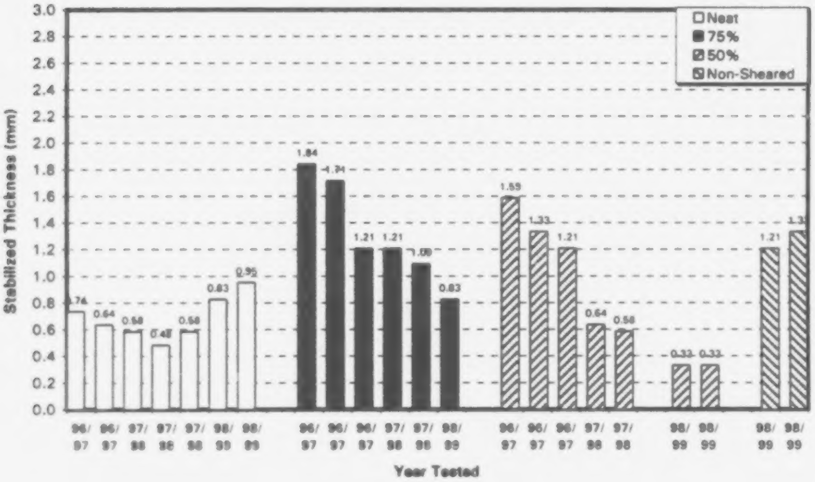
STABILIZED THICKNESS COMPARISON OF TYPE IV FLUIDS

1996 - 1999

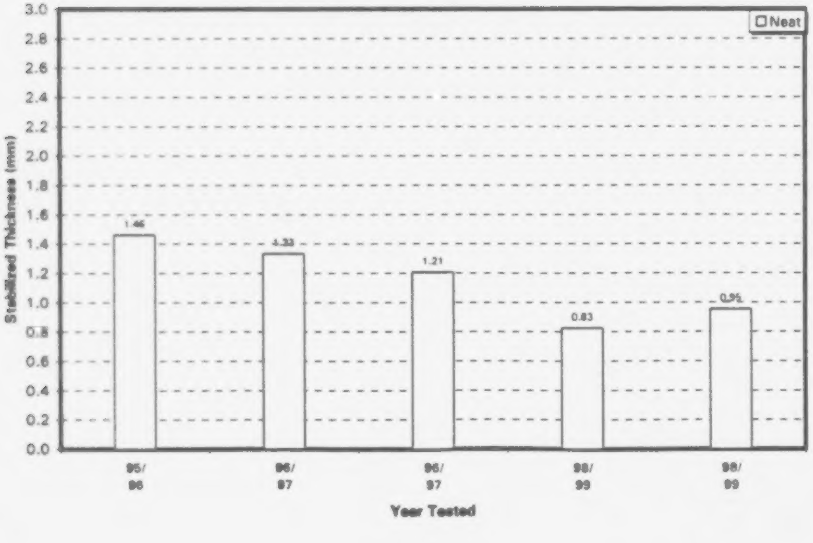
KILFROST ABC-S



OCTAGON MAX-FLIGHT



UCAR ULTRA+



5. HOLDOVER TIME TABLES, RESULTS AND DISCUSSIONS

The methods used to evaluate the test data were reviewed in Subsection 2.9. In this section, the officially accepted holdover time tables are presented, and important findings are discussed. Beginning with Type IV fluid results in Subsection 5.2, the different categories of precipitation are presented one at a time, in a cell-by-cell fashion. Comments and discussions follow. Type II fluids are discussed in Subsection 5.3, Type I in Subsection 5.4, and Type III in Subsection 5.5.

Subsection 5.6 presents all the holdover time tables, including the "generic" or SAE Type IV holdover time table and all six Type IV fluid-specific tables. These are the tables proposed for worldwide use during the 1999-2000 winter season.

5.1 Background

Six different Type IV fluids, each one representative of the manufacturer's lowest recommended on-wing viscosity, were provided to APS for 1998-99 testing. This included four fluids that had previously been tested: Kilfrost ABC-S, Octagon MaxFlight, Union Carbide Ultra+ and Clariant MPIV 1957. A limited number of tests using SPCA AD-480 in natural snow conditions were also conducted in order to complement the data set for this fluid from the previous test season. The results of fluid failure tests performed with these fluids were used to determine SAE holdover times for 1998-99.

Prior to the publication of the holdover time tables, APS was informed that one fluid, Clariant Safewing Four, which was tested extensively during the past test season, would not be available for production during the upcoming winter season. The results of this fluid have not been included in the production of the "generic" or SAE Type IV fluid holdover time table.

Clariant MPIV 1957 is a reformulation of the Hoechst MPIV 1957 fluid. In 1997-98, APS was notified that Hoechst MPIV 1957 was no longer commercially available. As a result, fluid-specific holdover times for MPIV 1957 fluid are solely those of the new Clariant formulation.

5.1.1 Type IV Fluid Viscosity

In 1996-97, fluid manufacturers provided mid-production range viscosity samples for fluid holdover time testing. During a meeting of the Workgroup on Laboratory Methods to Derive Holdover Time Guidelines in Montreal in November 1997, it was decided that low viscosity fluid samples should be tested in future holdover time tests. It was understood that this would result in more conservative holdover time values. Subsequently, APS requested that fluid manufacturers ship pre-sheared fluids that were representative of the lower end of the production viscosity range for 1997-98 test purposes.

Following several holdover time test sessions at the Dorval site in 1997-98, the results for Kilfrost fluid were found to be inferior to those obtained in previous tests conducted with the same fluid. As a result, APS examined the different batches of fluid delivered by the manufacturers. The Kilfrost fluid was found to have a viscosity level below the production range for this fluid. Examination of the viscosity levels of the other fluids revealed other inconsistencies. The fluid samples for Clariant MPIV 1957 and MPIV 2001 were believed to be at the low end of the production range for these fluids. The remainder of the fluid samples provided to APS had viscosity levels representative of the mid-production range, not the lower end of the production range as requested.

Prior to the start of freezing drizzle, light freezing rain, freezing fog, and rain on a cold-soaked wing testing at NRC's CEF in April 1998, APS requested that Kilfrost and Clariant provide mid-range viscosity fluids for these tests. This was done to ensure that all fluids were tested on even par. As a result, the holdover time testing conducted in 1997-98 was performed using mid-production range viscosity fluid.

For holdover time testing in 1998-99, manufacturers were asked to provide fluid samples representative of the lowest recommended on-wing viscosity. Upon reception of the individual fluid samples, APS personnel verified the fluid viscosity measurements obtained from the manufacturers. The fluid viscosity values obtained from the manufacturers and those obtained in viscosity tests conducted by APS are compared in Table 5.1.

Each manufacturer sent a sample of the fluid provided for holdover time testing to the Anti-icing Materials International Laboratory (AMIL) for WSET testing. The results of WSET tests are shown in Table 5.2.

The results of the WSET tests were discussed at the SAE G-12 meetings in Toronto. In order for a Type IV fluid to pass certification, it must achieve a minimum of 80 minutes in the WSET test. Several of the fluid samples tested by APS in 1998-99 had WSET results below the minimum, due to the shearing required to reduce the fluid viscosities for holdover time testing. After considerable discussion, the results of holdover time tests conducted with Clariant MPIV 1957, Octagon MaxFlight and Kilfrost-ABC-S were accepted, despite the fact that the samples had failed the WSET tests.

TABLE 5.1
FLUID VISCOSITY

FLUID	Manufacturer Value using Manufacturer Method (cP)	APS Value using Manufacturer Method (cP)*
Clariant 1957	16,000 20°C, 0.3 RPM, Spindle SC4-34/13R, 10 ml fluid, 15 min	16,200 20°C, 0.3 RPM, Spindle SC4-34/13R, 10 ml fluid, 15 min
Kilfrost ABC-II PLUS	3,500 20°C, 0.3 RPM, Spindle LV2, 150 ml beaker, 150 ml fluid, 10 min, grd.leg	3,600 20°C, 0.3 RPM, Spindle LV2, 250 ml beaker, 150 ml fluid, 10 min, grd.leg
Kilfrost ABC-S	17,000 20°C, 0.3 RPM, Spindle LV2, 150 ml beaker, 150 ml fluid, 10 min, grd.leg	17,000 20°C, 0.3 RPM, Spindle LV2, 250 ml beaker, 150 ml fluid, 10 min, grd.leg
Octagon Max-Flight	2,900 20°C, 0.3 RPM, Spindle LV1, 600 ml beaker, 500 ml fluid, 33 min 20 sec, grd.leg	2,920 20°C, 0.3 RPM, Spindle LV1, 600 ml beaker, 500 ml fluid, 33 min 20 sec, grd.leg
SPCA AD-480	20,500 20°C, 0.3 RPM, Spindle SC4-34/13R, 10 ml fluid, 30 min	21,200 20°C, 0.3 RPM, Spindle SC4-34/13R, 10 ml fluid, 30 min
UCAR Ultra +	38, 613 0°C, 0.3 RPM, Spindle SC4-31/13R, 10 ml fluid, 10 min	36,000 0°C, 0.3 RPM, Spindle SC4-31/13R, 10 ml fluid, 10 min

*This value will appear with the fluid brand specific HOT tables.

TABLE 5.2

WSET VALUES OF SAMPLES TESTED (FIRST ICE EVENT)

FLUID	MINUTES
Clariant Safewing 1957	70, 70, 69
Clariant 2001	81
Kilfrost ABC-II PLUS	61, 62, 61
Kilfrost ABC-S	78, 83, 76
Octagon Max-Flight	78, 96, 101
SPCA AD-480	95, 92, 90
UCAR Ultra+	101, 95, 94, 94, 93, 99, 94, 94, 93

To obtain a fluid-specific table for their fluid, manufacturers were required to conduct holdover time tests in 1998-99 using a lowest on-wing viscosity regardless of whether the fluid had been tested previously. The manufacturers of two fluids, Clariant and SPCA, insisted that the Clariant MPIV 2001 and SPCA AD-480 fluids delivered for testing in 1997-98 were representative of the manufacturer's recommended lowest on-wing viscosity. As a result, no holdover time testing was conducted using these two fluids in order to generate fluid-specific values. A small quantity of testing with the SPCA AD-480 fluid was conducted in natural snow, however, to complete the database from the previous year.

At the Holdover Time Subcommittee meeting in Toronto, Clariant was asked to provide a sample of the MPIV 2001 fluid sent to APS for holdover time testing in 1997-98 to AMIL for WSET verification. The average WSET of the sheared sample was 81 minutes. A sample was also provided to APS for viscosity testing. The viscosity measurement obtained by APS (18,000 cp, 20°C, 0.3 Revolutions Per Minute (RPM), Spindle SC4-34/13R, 10 mL fluid, 15 minutes) will appear in the fluid-specific holdover time table for Clariant MPIV 2001.

The viscosity of the low-viscosity fluid sample used in holdover time testing, as measured by APS personnel, now appears on the fluid-specific holdover time table for any given fluid. The instrument spindle, chamber size, temperature and RPM are also documented along with the viscosity measurement. In order for the fluid-specific values of a fluid to be valid, operators must ensure that the viscosity of the fluid used is superior to the published viscosity of that fluid, using the same viscosity measurement method published.

Viscosity measurements of the various anti-icing fluids obtained by APS during the 1998-99 test season were not all performed using the same method and spindles as the manufacturers had employed when conducting in-house viscosity measurements. In most cases, APS employed a common method when conducting viscosity measurements (Spindle SC4-31/13R, 20°C, 33 minutes and 20 seconds, 0.3 RPM, and 10 mL of fluid). The use of this approach caused much confusion at the SAE G-12 Holdover Time Subcommittee meeting in Toronto, as the fluid viscosities documented by APS and the fluid manufacturers did not compare. After much discussion, it was resolved that APS would re-measure all anti-icing fluid viscosities using the same method employed by the manufacturers. The re-measured viscosities were published in Table 5.1. One additional spindle was purchased to complete these viscosity measurements.

It has been recommended by a fluid manufacturer that the manufacturer's measured fluid viscosity be indicated on the fluid-specific holdover time table and not that measured by APS. Instead, APS would be responsible for ensuring that the viscosity of the fluid sent for holdover time testing is within acceptable error of that measured by the manufacturer.

5.2 Type IV Fluids

Six Type IV fluids from four different manufacturers were tested during the winter 1998-99 test season. Clariant Safewing Four was later removed from this list after the manufacturer indicated that the fluid would not be produced in the upcoming year. In total, eight different fluids, tested since 1996-97, were used to develop the SAE holdover time table for Type IV fluid: Clariant MPIV 1957, Clariant MPIV 2001, Hoechst MPIV 1957, Kilfrost-ABC-S, Octagon MaxFlight, SPCA AD-404, SPCA AD-480, and Union Carbide Ultra+.

The results of Type IV tests conducted in 1998-99 are shown in Figures 5.1 to 5.27. The results of tests conducted in 1996-97 and 1997-98 are shown in Appendix R.

5.2.1 Methodology Used in the Determination of Fluid-Specific Holdover Times

The different methodologies and holdover time values used in the determination of Type IV *fluid-specific* holdover times, for use in 1999-2000 operations, are explained in this section on an individual fluid basis.

5.2.1.1 Clariant MPIV 1957

- Freezing fog holdover time values are those of 1998-99 testing with Clariant MPIV 1957 fluid;
- Light freezing rain, freezing drizzle, snow and rain on a cold-soaked wing values are the lowest numbers from 1997-98 and 1998-99 testing with this fluid; and
- Hoechst MPIV 1957 values have not been included.

5.2.1.2 Clariant MPIV 2001

- Freezing fog holdover time values are those of the approved 1999-2000 SAE generic Type IV table; and
- Light freezing rain, freezing drizzle, snow and rain on a cold-soaked wing values are those of the 1997-98 tests conducted with this fluid.

5.2.1.3 Kilfrost ABC-S

- Freezing fog holdover time values are those of 1998-99 testing with this fluid;
- Light freezing rain, freezing drizzle, and snow values are the lowest numbers from 1996-97,1997-98 and 1998-99 testing with this fluid; and
- Rain on a cold-soaked wing values are the lowest results of 1997-98 and 1998-99 testing with this fluid.

5.2.1.4 Octagon Max-Flight

- Freezing fog holdover time values are those of 1998-99 testing with this fluid;
- Light freezing rain, freezing drizzle, and snow values are the lowest numbers from 1996-97,1997-98 and 1998-99 testing with this fluid; and
- Rain on a cold-soaked wing values are the lowest results of 1997-98 and 1998-99 testing with this fluid.

5.2.1.5 SPCA AD-480

- Freezing fog holdover time values are those of the approved 1999-2000 SAE generic Type IV table;
- Light freezing rain, freezing drizzle, and rain on a cold-soaked wing values are those of 1997-98 tests conducted with this fluid;
- Snow holdover time values are those of the combined 1997-98 and 1998-99 testing with this fluid; and
- For snow above 0°C for neat and 75/25 fluid, the endurance times were lowered from those generated by the evaluation method; this precautionary measure is supported by the data.

5.2.1.6 Union Carbide Ultra+

- Freezing fog holdover time values are those of 1998-99 testing with this fluid;

- Light freezing rain, freezing drizzle and snow holdover time values are the lowest results of 1996-97 and 1998-99 testing with this fluid; and
- Rain on a cold-soaked wing values are those of 1998-99 testing conducted with this fluid.

5.2.2 Natural Snow

The natural snow holdover time data originated from tests conducted by APS at the Dorval Airport test facility. The fluid failure time versus precipitation rate data have been plotted either as a function of temperature or as a function of fluid brand (Appendix F). The latter plot format lends itself more easily to the cell-by-cell presentation of results for each category of precipitation. It is used here to present the changes proposed to the holdover times and to allow direct comparison with the numbers obtained from the regression analyses.

The following subsection contains the Type IV fluid holdover time results in the snow column. They are arranged in tabular form and follow the sequence of temperature ranges as they appear in the holdover time tables, from top to bottom.

5.2.2.1 Changes to Type IV Fluid Holdover Times for Snow

The results of Type IV fluid testing from 1996-97, 1997-98, and 1998-99 are presented in this section. The first horizontal row of values in each of the following tables contains the SAE and fluid-specific holdover time values used in 1997-98, a result of tests conducted in 1996-97. The second line in each table contains the holdover time results from 1997-98 testing. The third line contains the SAE and fluid-specific holdover time results that were used in winter operations in 1998-99. The fourth set of values are the holdover time test results from 1998-99 testing. The final row in each table contains the SAE and fluid-specific holdover time values accepted for use in 1999-2000 winter operations. The underlined holdover time values in each of the tables indicate the fluid(s) responsible for the SAE holdover time.

Due to space limitations, the following fluid codes will be used in each of the tables:

Fluid	Code
Hoechst MPIV 1957	H-1957
Kilfrost ABC-S	K-ABC-S
Octagon Max-Flight	Oct Max
Union Carbide Ultra+	Ultra+
Clariant MPIV 1957	C-1957
Clariant MPIV 2001	C-2001
SPCA AD-404	S-404
SPCA AD-480	S-480

i. Neat fluid, above 0°C, snow (Figure 5.1)

Snow Above 0°C	SAE	Oct Max	K-ABC-S	C-1957	H-1957	Ultra+	S-480	C-2001	S-404
1996-97 Test Results and Tables used in 1997-98	0:45-1:25	1:15-2:00	1:10-2:00		0:45-1:25	0:50-1:40			
1997-98 Test Results				1:05-2:00			1:10-2:00	1:55-2:00	1:40-2:00
1998-99 Tables	0:45-1:25	1:15-2:00	1:10-2:00	1:05-2:00		0:50-1:40	1:10-2:00	1:55-2:00	1:40-2:00
1998-99 Test Results		1:00-1:30	1:10-2:00	0:35-1:05		0:40-1:25	1:45-2:00		
1999-2000 Tables	0:35-1:05	1:00-1:30	1:10-2:00	0:35-1:05		0:40-1:25	1:10-2:00	1:55-2:00	

The SAE holdover times in this cell were reduced based on the result of the low-viscosity Clariant MPIV 1957 fluid. Several upper holdover times were limited to two hours in order to prevent the appearance of excessively long times in the holdover time tables. The fluid-specific values for four of the six Type IV fluids tested in 1998-99 were reduced from the previous year. Due to a lack of data above 0°C, the lower holdover time for SPCA AD-480 was reduced to match the 1998-99 fluid-specific value for this fluid.

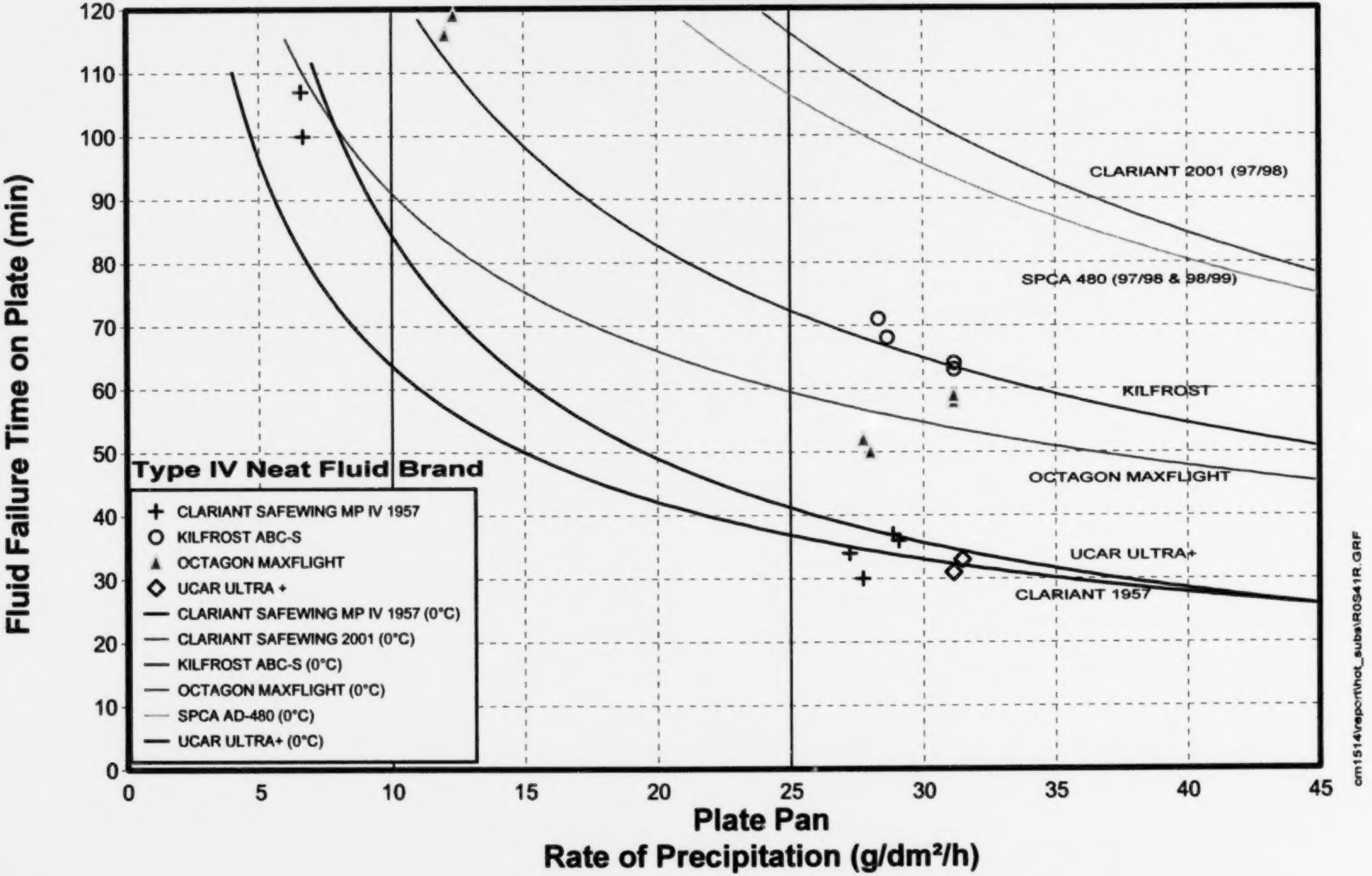
FIGURE 5.1

EFFECT OF FLUID BRAND AND RATE OF PRECIPITATION ON ENDURANCE TIME

TYPE IV NEAT (above 0°C)

NATURAL SNOW CONDITIONS

Number of Tests: 22



ii. 75/25 fluid, above 0°C, snow (Figure 5.2)

Snow Above 0°C	SAE	Oct Max	K-ABC-S	C-1957	H-1957	Ultra+ (do not use)	S-480	C-2001	S-404
1996-97 Test Results and Tables used in 1997-98	0:20-0:40	1:20-2:00	0:35-1:05		0:35-1:10	0:20-0:40			
1997-98 Test Results				0:45-1:25			1:00-1:55	0:50-1:25	0:50-1:45
1998-99 Tables	0:20-0:40	1:20-2:00	0:35-1:05	0:45-1:25			1:00-1:55	0:50-1:25	0:50-1:45
1998-99 Test Results		0:40-1:30	0:30-1:05	0:35-1:05			0:45-1:25		
1999-2000 Tables	0:20-0:40	0:40-1:30	0:30-1:05	0:35-1:05			0:45-1:25	0:50-1:25	

The SAE holdover time numbers in this cell remain unchanged from last year, and are based on the results of diluted Ultra+ fluid, tested in 1996-97. Prior to the publication of the 1997-98 holdover time tables, Union Carbide transmitted a notice stating that diluted forms of Ultra+ were no longer recommended for operational use due to performance deficiencies noted in qualifying tests. Holdover times for dilutions of this fluid will continue to be presented in this report only for the purpose of identifying the fluid(s) responsible for the SAE holdover times.

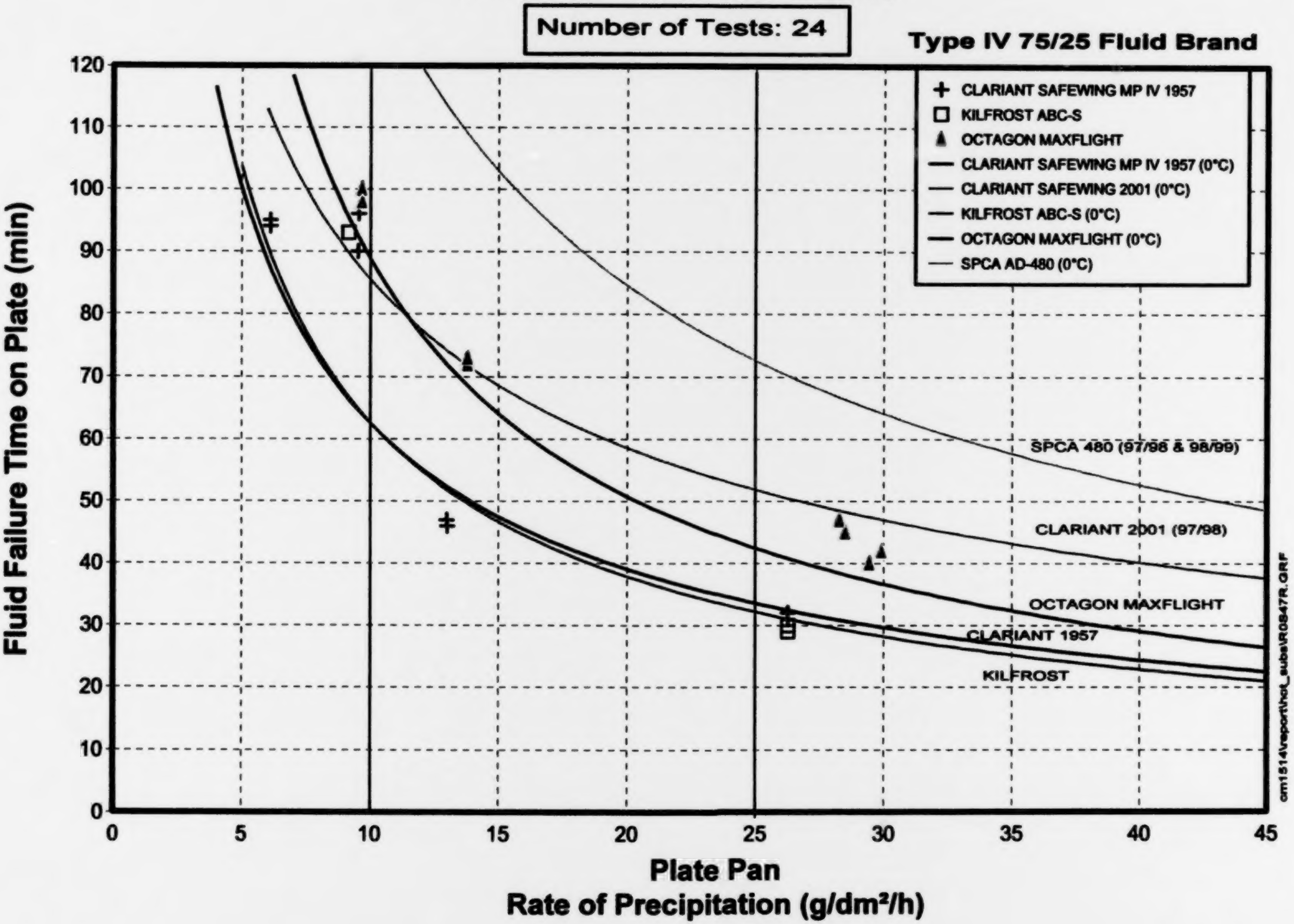
The SPCA AD-480 fluid-specific holdover times in this cell were reduced based on the results on tests conducted during the past year.

FIGURE 5.2

EFFECT OF FLUID BRAND AND RATE OF PRECIPITATION ON ENDURANCE TIME

TYPE IV 75/25 (above 0°C)

NATURAL SNOW CONDITIONS



iii. 50/50 fluid, above 0°C, snow (Figure 5.3)

Snow Above 0°C	SAE	Oct Max	K-ABC-S	C-1957	H-1957	Ultra+ (do not use)	S-480	C-2001	S-404
1996-97 Test Results and Tables used in 1997-98	0:05-0:20	0:40-1:20	0:05-0:20		0:15-0:25	0:05-0:20			
1997-98 Test Results				0:15-0:30			0:15-0:35	0:10-0:20	0:20-0:45
1998-99 Tables	0:05-0:20	0:40-1:20	0:05-0:20	0:15-0:30			0:15-0:35	0:10-0:20	0:20-0:45
1998-99 Test Results		0:15-0:35	0:10-0:20	0:15-0:30					
1999-2000 Tables	0:05-0-20	0:15-0:35	0:05-0:20	0:15-0:30			0:15-0:35	0:10-0:20	

The SAE holdover times in this cell are unchanged from last year. Kilfrost fluid has been responsible for the SAE holdover times over the past three years. No tests were conducted with the 50/50 sample of SPCA AD-480 during the past year.

iv. Neat fluid, 0°C to -3°C, snow (Figure 5.4)

Snow 0 to -3°C	SAE	Oct Max	K-ABC-S	C-1957	H-1957	Ultra+	S-480	C-2001	S-404
1996-97 Test Results and Tables used in 1997-98	0:35-1:00	0:50-1:35	1:00-1:40		0:35-1:00	0:35-1:15			
1997-98 Test Results				0:45-1:25			1:05-2:00	1:00-1:55	1:00-1:45
1998-99 Tables	0:35-1:00	0:50-1:35	1:00-1:40	0:45-1:25		0:35-1:15	1:05-2:00	1:00-1:55	1:00-1:45
1998-99 Test Results		0:50-1:20	1:00-1:40	0:30-0:55		0:35-1:15	1:05-1:50		
1999-2000 Tables	0:30-0:55	0:50-1:20	1:00-1:40	0:30-0:55		0:35-1:15	1:05-1:50	1:00-1:55	

The upper and lower SAE holdover times at this temperature and concentration were reduced by 5 minutes due to the performance of one fluid, tested during the past test season. The upper fluid-specific holdover time value for SPCA AD-480 was reduced slightly due to the results of this year's tests.

FIGURE 5.3
EFFECT OF FLUID BRAND AND RATE OF PRECIPITATION ON ENDURANCE TIME
TYPE IV 50/50 (above 0°C)
NATURAL SNOW CONDITIONS

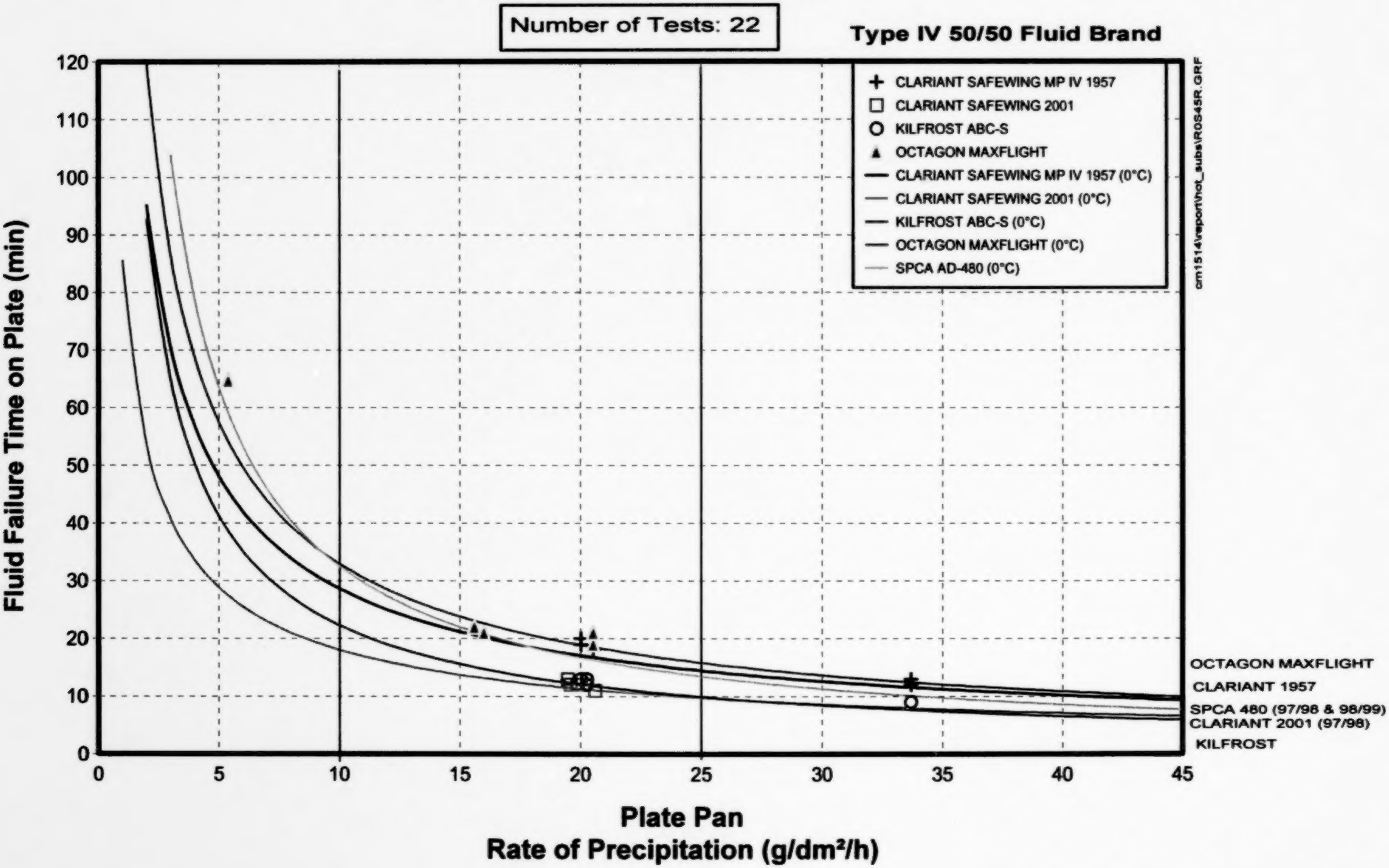
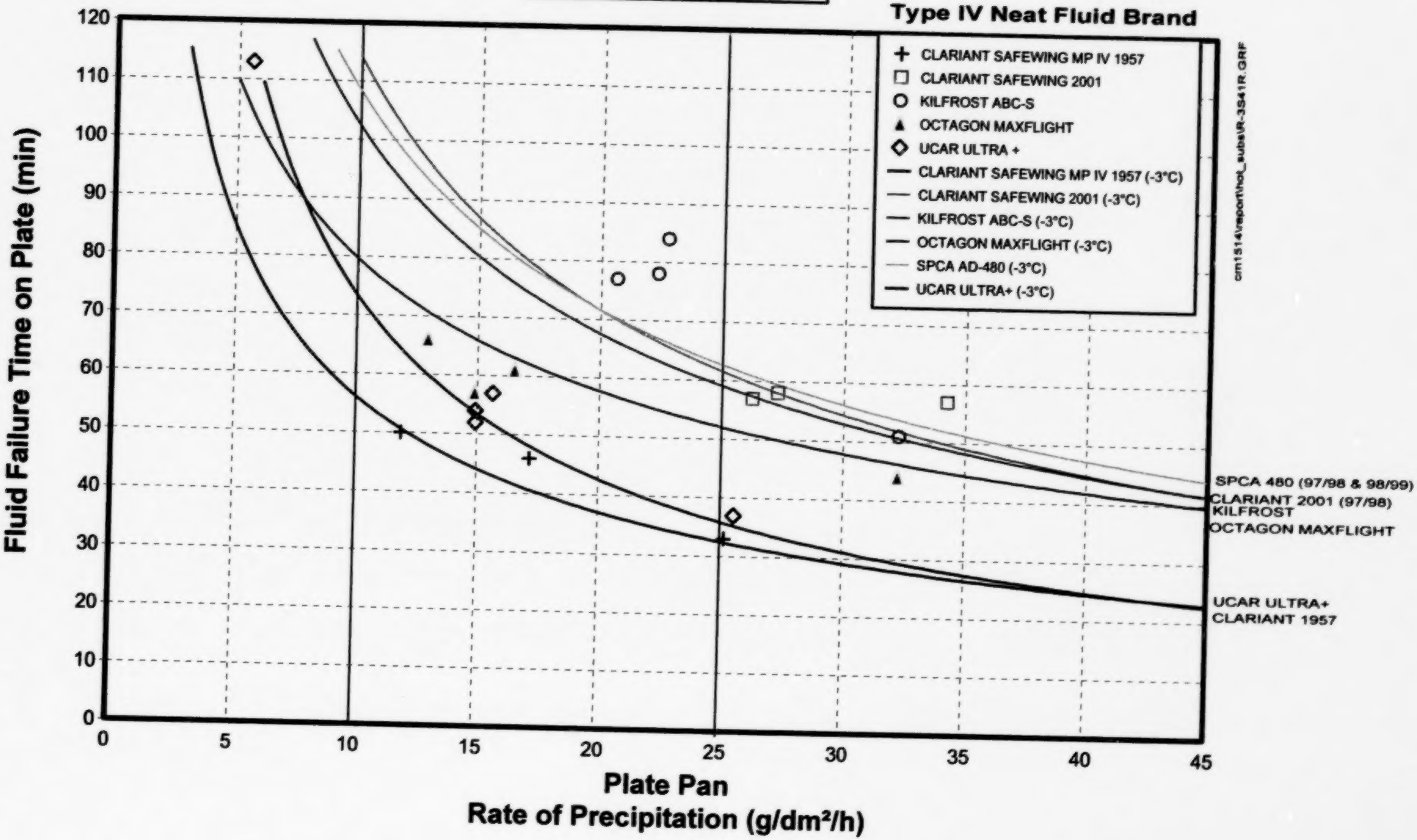


FIGURE 5.4

EFFECT OF FLUID BRAND AND RATE OF PRECIPITATION ON ENDURANCE TIME

TYPE IV NEAT (0 to -3°C)
NATURAL SNOW CONDITIONS

Number of Tests: 24



v. 75/25 fluid, 0°C to -3°C, snow (Figure 5.5)

Snow 0 to -3°C	SAE	Oct Max	K-ABC-S	C-1957	H-1957	Ultra + (do not use)	S-480	C-2001	S-404
1996-97 Test Results and Tables used in 1997-98	0:20-0:35	0:45-1:45	0:35-1:05		0:25-0:50	0:20-0:35			
1997-98 Test Results				0:30-1:00			0:45-1:25	0:35-1:00	0:25-1:00
1998-99 Tables	0:20-0:35	0:45-1:45	0:35-1:05	0:30-1:00			0:45-1:25	0:35-1:00	0:25-1:00
1998-99 Test Results		0:30-1:00	0:30-0:55	0:30-0:50			0:45-1:25		
1999-2000 Tables	0:20-0:35	0:30-1:00	0:30-0:55	0:30-0:50			0:45-1:25	0:35-1:00	

At this dilution, the holdover performances of the fluids were similar, with the exception of SPCA AD-480, which slightly outperformed the rest. In general, the fluid-specific holdover times of the fluids tested in 1998-99 are lower than those tested in the previous year. The lower and upper SAE holdover times were those of diluted Ultra+, tested in 1996-97.

vi. 50/50 fluid, 0°C to -3°C, snow (Figure 5.6)

Snow 0 to -3°C	SAE	Oct Max	K-ABC-S	C-1957	H-1957	Ultra + (do not use)	S-480	C-2001	S-404
1996-97 Test Results and Tables used in 1997-98	0:05-0:15	0:40-1:20	0:05-0:15		0:15-0:25	0:05-0:15			
1997-98 Test Results		0:40-1:20	0:05-0:15	0:10-0:20			0:10-0:30	0:10-0:20	0:15-0:30
1998-99 Tables	0:05-0:15	0:40-1:20	0:05-0:15	0:10-0:20			0:10-0:30	0:10-0:20	0:15-0:30
1998-99 Test Results	0:05-0:15	0:15-0:30	0:05-0:15	0:10-0:20					
1999-2000 Tables	0:05-0:15	0:15-0:30	0:05-0:15	0:10-0:20			0:10-0:30	0:10-0:20	

FIGURE 5.5

EFFECT OF FLUID BRAND AND RATE OF PRECIPITATION ON ENDURANCE TIME

TYPE IV 75/25 (0 to -3°C)

NATURAL SNOW CONDITIONS

Number of Tests: 18

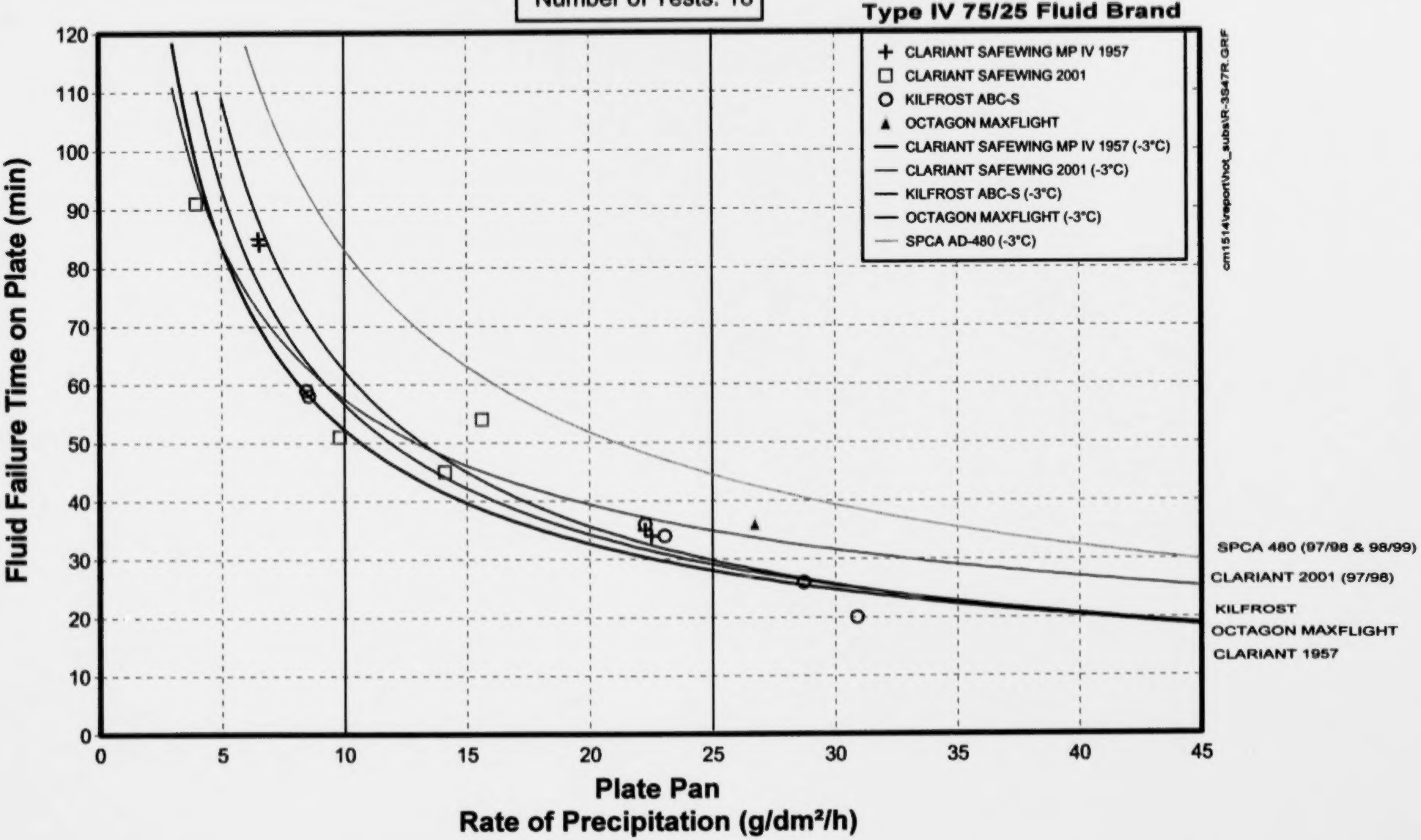
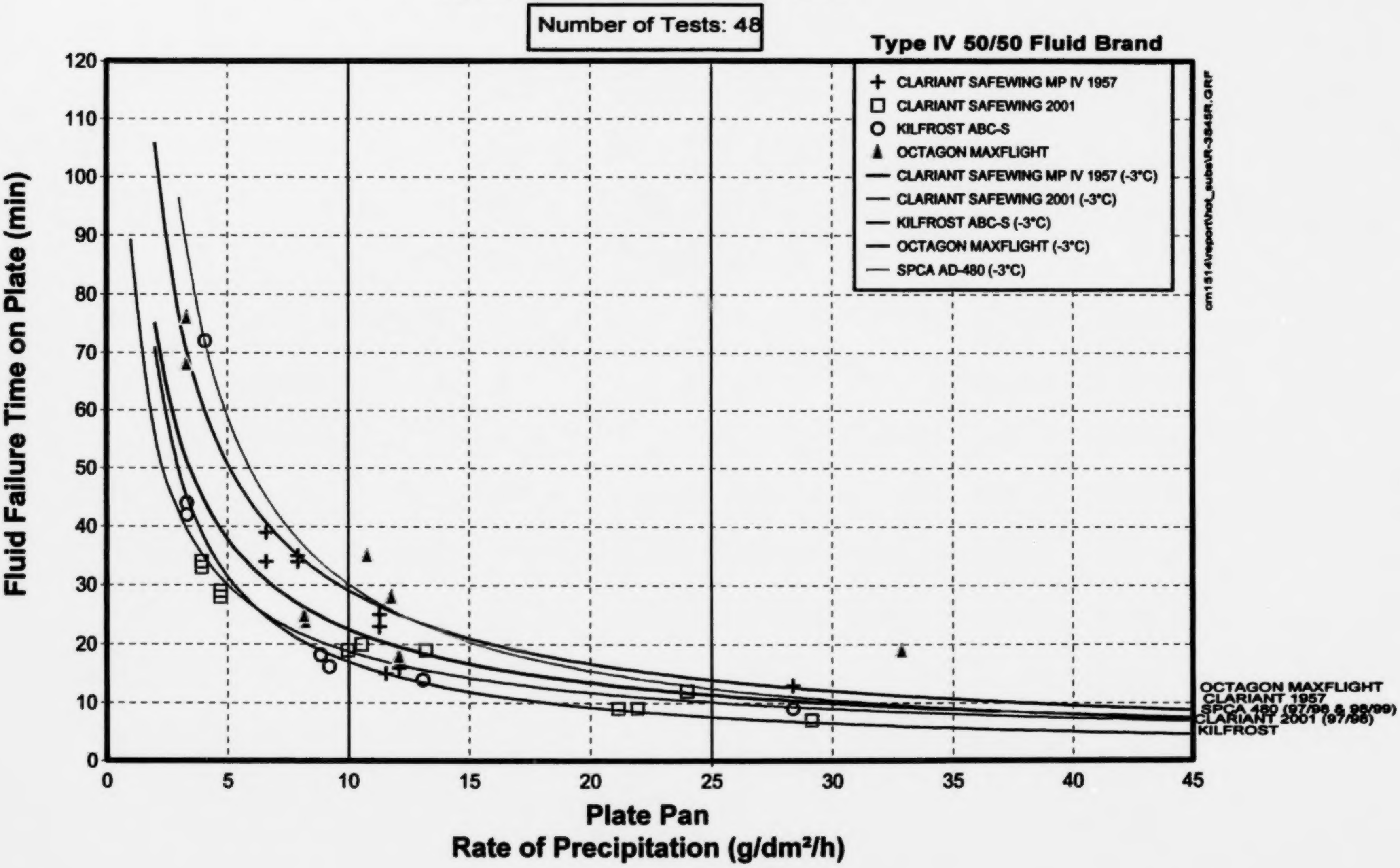


FIGURE 5.6
EFFECT OF FLUID BRAND AND RATE OF PRECIPITATION ON ENDURANCE TIME
TYPE IV 50/50 (0 to -3°C)
NATURAL SNOW CONDITIONS



The holdover time performances of the various fluids are quite similar at this dilution and temperature range, with the exception of one fluid that outperforms the rest (see Figure 5.6). The SAE holdover times were based on the Kilfrost and Ultra+ fluids. In addition, the fluid-specific values for Octagon Max-Flight were significantly reduced based on the results on 1998-99 tests with low-viscosity fluid.

vii. Neat fluid, -3°C to -14°C, snow (Figure 5.7)

Snow -3 to -14°C	**SAE**	**Oct Max**	**K-ABC-S**	**C-1957**	**H-1957**	**Ultra+**	**S-480**	**C-2001**	**S-404**
1996-97 Test Results and Tables used in 1997-98	0:20-0:40	0:25-0:50	0:45-1:20		0:20-0:40	0:25-0:55			
1997-98 Test Results				0:30-0:55			0:20-0:40	0:30-0:50	0:35-1:00
1998-99 Tables	0:20-0:40	0:25-0:50	0:45-1:20	0:30-0:55		0:25-0:55	0:20-0:40	0:30-0:50	0:35-1:00
1998-99 Test Results		0:45-1:05	0:45-1:20	0:30-0:50		0:30-1:00	0:30-0:55		
1999-2000 Tables	0:20-0:40	0:25-0:50	0:45-1:20	0:30-0:50		0:25-0:55	0:30-0:55	0:30-0:50	

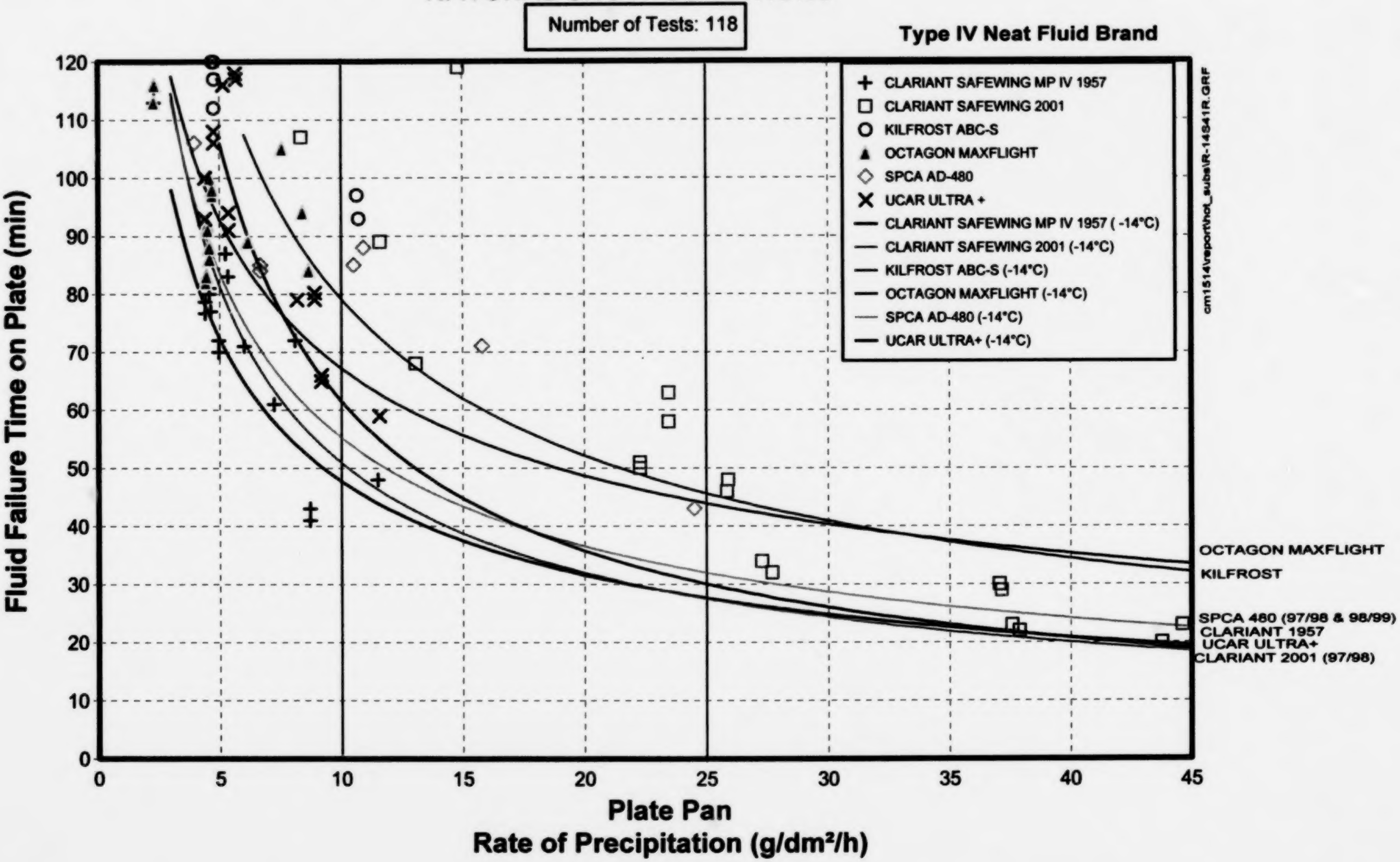
The SAE holdover times for this temperature range and concentration are, once again, driven by test results obtained in previous years. In 1998-99, the SPCA AD-480 holdover time range was reduced to equal that of the SAE holdover time range due to a lack of data points for this fluid below -7°C. During the past season, tests with this fluid were conducted and the holdover times were increased from the generic numbers.

FIGURE 5.7

EFFECT OF FLUID BRAND AND RATE OF PRECIPITATION ON ENDURANCE TIME

TYPE IV NEAT (-3 to -14°C)

NATURAL SNOW CONDITIONS



viii. 75/25 fluid, -3° C to -14°C, snow (Figure 5.8)

Snow -3 to -14°C	SAE	Oct Max	K-ABC-S	C-1957	H-1957	Ultra + (do not use)	S-480	C-2001	S-404
1996-97 Test Results and Tables used in 1997-98	0:15-0:30	0:20-0:50	0:35-1:05		0:15-0:30	0:15-0:30			
1997-98 Test Results				0:20-0:40			0:15-0:25	0:20-0:35	0:15-0:25
1998-99 Tables	0:15-0:25	0:20-0:50	0:35-1:05	0:20-0:40			0:15-0:25	0:20-0:35	0:15-0:25
1998-99 Test Results		0:20-0:40	0:25-0:50	0:20-0:40			0:25-0:45		
1999-2000 Tables	0:15-0:25	0:20-0:40	0:25-0:50	0:20-0:40			0:25-0:45	0:20-0:35	

The SAE upper and lower holdover times in this cell remain the same from last year, and are driven by fluids that are no longer available. In general, the holdover time performances of the various fluids in this cell are similar. In 1998-99, the SPCA AD-480 holdover time range was reduced to equal that of the SAE holdover time range due to a lack of data points for this fluid below -7°C. During the past season, tests with this fluid were conducted and the holdover times were increased from the generic numbers.

ix. Neat fluid, -14°C to -25°C, snow (Figure 5.9)

Snow -14 to -25°C	SAE	Oct Max	K-ABC-S	C-1957	H-1957	Ultra +	S-480	C-2001	S-404
1996-97 Test Results and Tables used in 1997-98	0:15-0:30	0:20-0:40	0:40-1:10		0:15-0:30	0:20-0:45			
1997-98 Test Results				0:25-0:45			0:15-0:30	0:20-0:35	0:15-0:30
1998-99 Tables	0:15-0:30	0:20-0:40	0:40-1:10	0:25-0:45		0:20-0:45	0:15-0:30	0:20-0:35	0:15-0:30
1998-99 Test Results		0:40-1:00	0:40-1:10	0:25-0:45		0:30-0:55	0:25-0:40		
1999-2000 Tables	0:15-0:30	0:20-040	0:40-1:10	0:25-0:45		0:20-0:45	0:25-0:40	0:20-0:35	

FIGURE 5.8

EFFECT OF FLUID BRAND AND RATE OF PRECIPITATION ON ENDURANCE TIME

TYPE IV 75/25 (-3 to -14°C)

NATURAL SNOW CONDITIONS

Number of Tests: 102

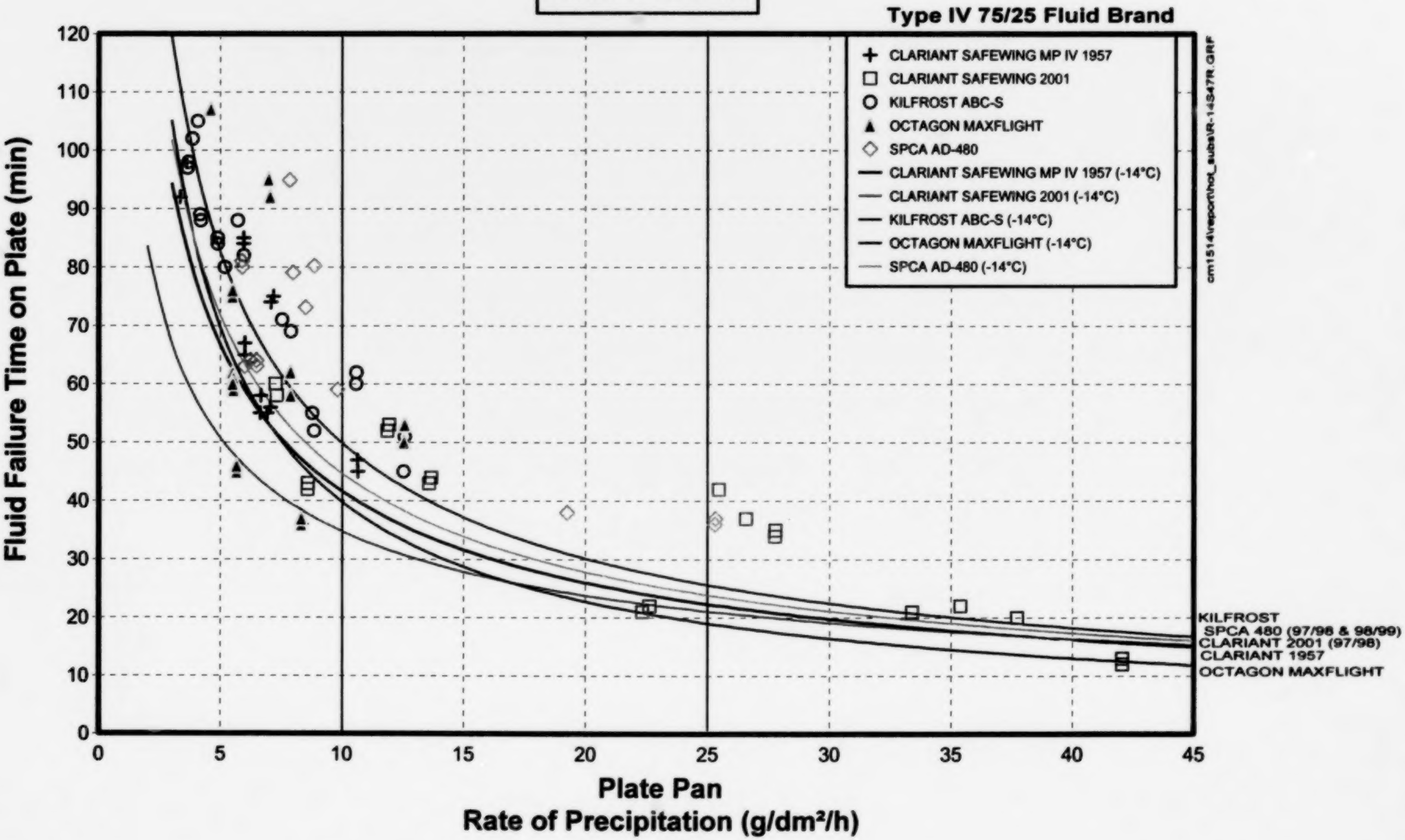
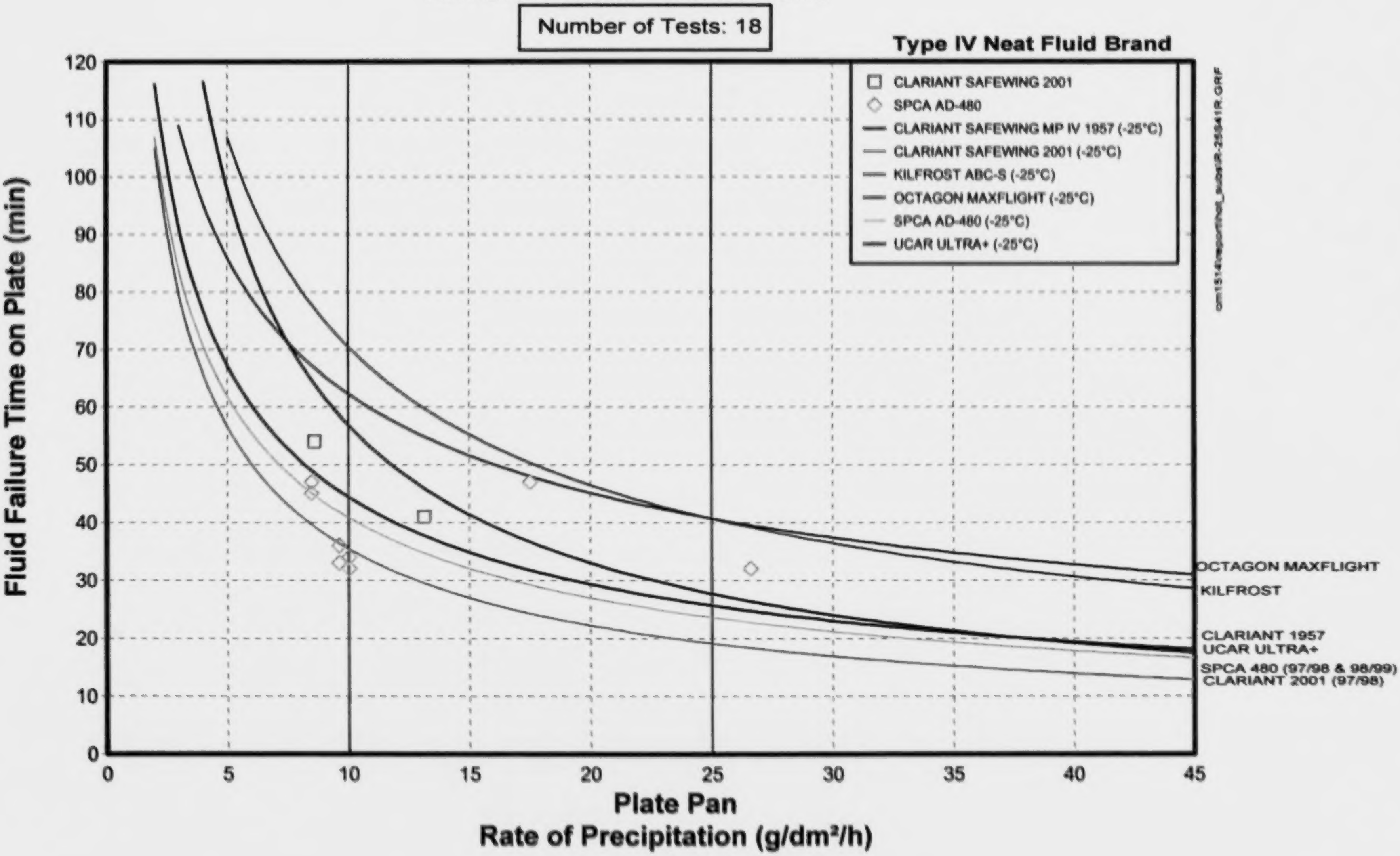


FIGURE 5.9
EFFECT OF FLUID BRAND AND RATE OF PRECIPITATION ON ENDURANCE TIME

TYPE IV NEAT (-14 to -25°C)
NATURAL SNOW CONDITIONS



The SAE holdover times for this cell are unchanged from last year and are driven by results from the1996-97 test season. Regression curves were generated using the most restrictive temperature in this range (-25°C). In 1998-99, the holdover times for SPCA AD-404 and SPCA AD-480 in this cell were reduced to match the SAE holdover times, due to a lack of data points. The SPCA AD-480 holdover times were increased based on the results of tests conducted during the past year.

5.2.2.2 Overall Perspective on Snow Results

Four changes were made to the snow column of the generic or SAE Type IV holdover time tables based on the results of tests conducted in 1998-99. The four reductions range from 5 to 20 minutes, and are the result of tests conducted with one low-viscosity fluid.

5.2.3 Freezing Drizzle

The following is a cell-by-cell summary of the holdover time performance of all Type IV fluid brands tested under conditions of simulated freezing drizzle. The results are arranged in the sequence of temperature ranges (from top to bottom) that appear in the corresponding columns of the holdover time tables. Because it was not possible to simulate freezing drizzle above 0°C, the holdover time results for this category of precipitation above 0°C are identical to those in the range of 0°C to -3°C.

The first horizontal row of values in each of the following tables contains the SAE and fluid-specific holdover time values used in 1997-98, a result of tests conducted in 1996-97. The second line in each table contains the holdover time results from 1997-98 testing. The third line contains the SAE and fluid-specific holdover time results that were used in winter operations in 1998-99. The fourth set of values consists of the holdover time test results from 1998-99 testing. The final row in each table contains the SAE and fluid-specific holdover time values accepted for use in 1999-2000 winter operations. The underlined holdover time values in each of the tables indicate the fluid(s) responsible for the SAE holdover time.

The fluid failure time versus precipitation rate data for this category of precipitation are plotted either as a function of temperature or as a function of fluid brand. The plots as a function of fluid brand are used to help present discussions regarding changes to holdover times and appear in the body of the text as Figures 5.10 to 5.14.

5.2.3.1 Changes to Type IV Fluid Holdover Times for Freezing Drizzle

i. Neat fluid, above 0°C and 0 to -3°C, freezing drizzle (Figure 5.10)

Freezing Drizzle Above 0°C, 0 to -3°C	**SAE**	**Oct Max**	**K-ABC-S**	**C-1957**	**H-1957**	**Ultra+**	**S-480**	**C-2001**	**S-404**
1996-97 Test Results and Tables used in 1997-98	0:40-1:00	0:55-2:00	1:20-1:50		0:40-1:00	1:00-2:00			
1997-98 Test Results		1:10-2:00	1:55-2:00	0:50-1:40			1:05-2:00	0:55-1:55	1:40-2:00
1998-99 Tables	0:40-1:00	0:55-2:00	1:20-1:50	0:50-1:40		1:00-2:00	1:05-2:00	0:55-1:55	1:40-2:00
1998-99 Test Results		1:00-1:55	2:00-2:00	0:40-1:10		0:45-1:35			
1999-2000 Tables	0:40-1:00	0:55-1:55	1:20-1:50	0:40-1:10		0:45-1:35	1:05-2:00	0:55-1:55	

The SAE holdover times in the two cells remain unchanged from last year and are based on the results of tests conducted in 1996-97. One fluid tested during the past year displayed performance equal to the lower SAE holdover time. The fluids in this cell displayed widely varying holdover times. The upper fluid-specific value for SPCA AD-480 was rounded off at two hours (Figure 5.10).

ii. 75/25 fluid, above 0°C and 0 to -3°C, freezing drizzle (Figure 5.11)

Freezing Drizzle Above 0°C, 0 to -3°C	**SAE**	**Oct Max**	**K-ABC-S**	**C-1957**	**H-1957**	**Ultra+ (do not use)**	**S-480**	**C-2001**	**S-404**
1996-97 Test Results and Tables used in 1997-98	0:30-1:00	1:15-2:00	0:50-1:25		0:40-1:05	0:30-1:00			
1997-98 Test Results		1:20-2:00	0:50-1:10	0:45-1:15			0:50-1:20	0:35-1:10	0:50-1:50
1998-99 Tables	0:30-1:00	1:15-2:00	0:50-1:10	0:45-1:15			0:50-1:20	0:35-1:10	0:50-1:50
1998-99 Test Results		0:50-1:20	0:45-1:10	0:35-1:05					
1999-2000 Tables	0:30-1:00	0:50-1:20	0:45-1:10	0:35-1:05			0:50-1:20	0:35-1:10	

FIGURE 5.10

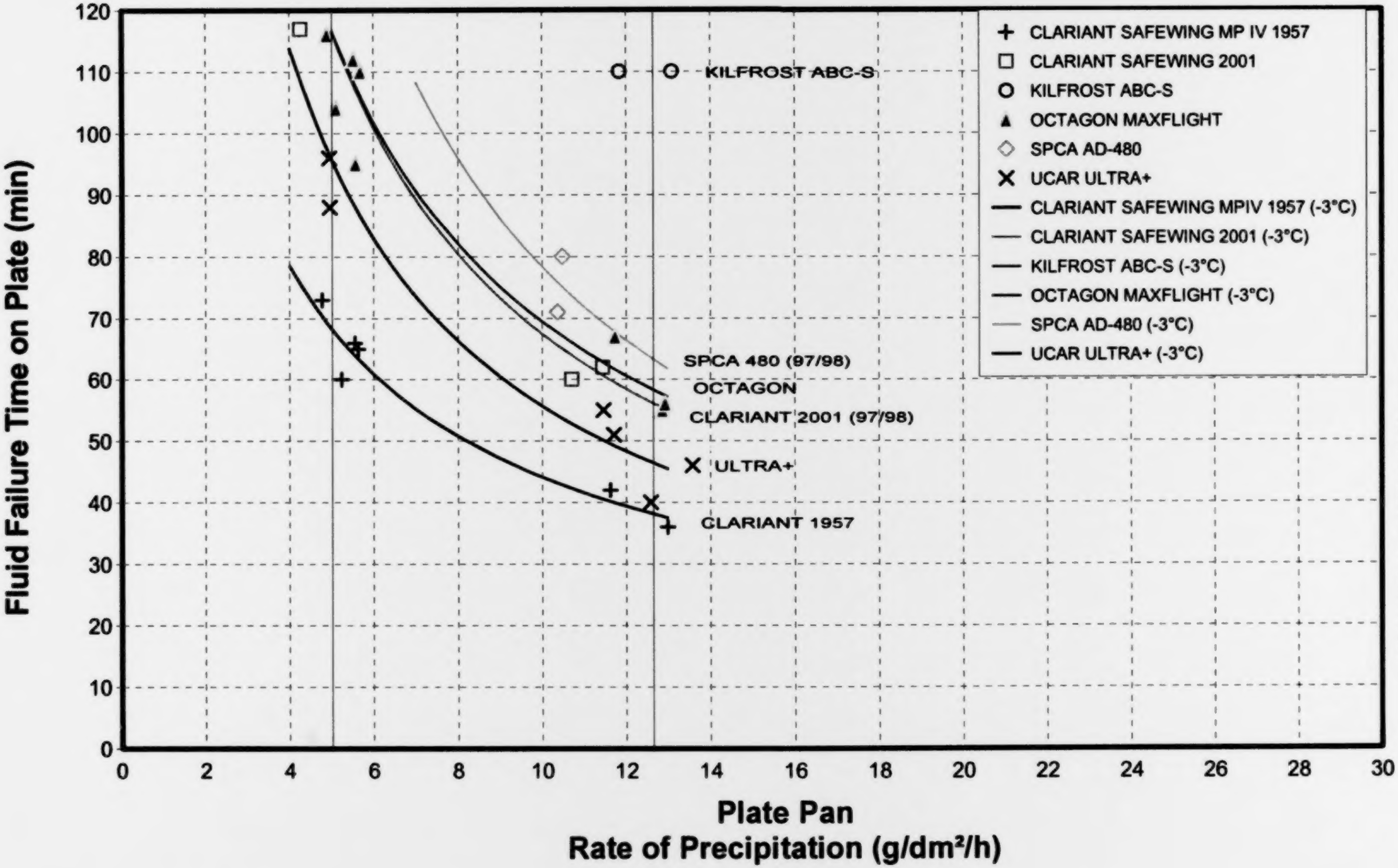
EFFECT OF FLUID BRAND AND RATE OF PRECIPITATION ON ENDURANCE TIME

TYPE IV NEAT

SIMULATED FREEZING DRIZZLE AT -3°C

1998-99

Number of Tests: 38



cm1514/report/hot_subs/ZD-3_4N.GRF

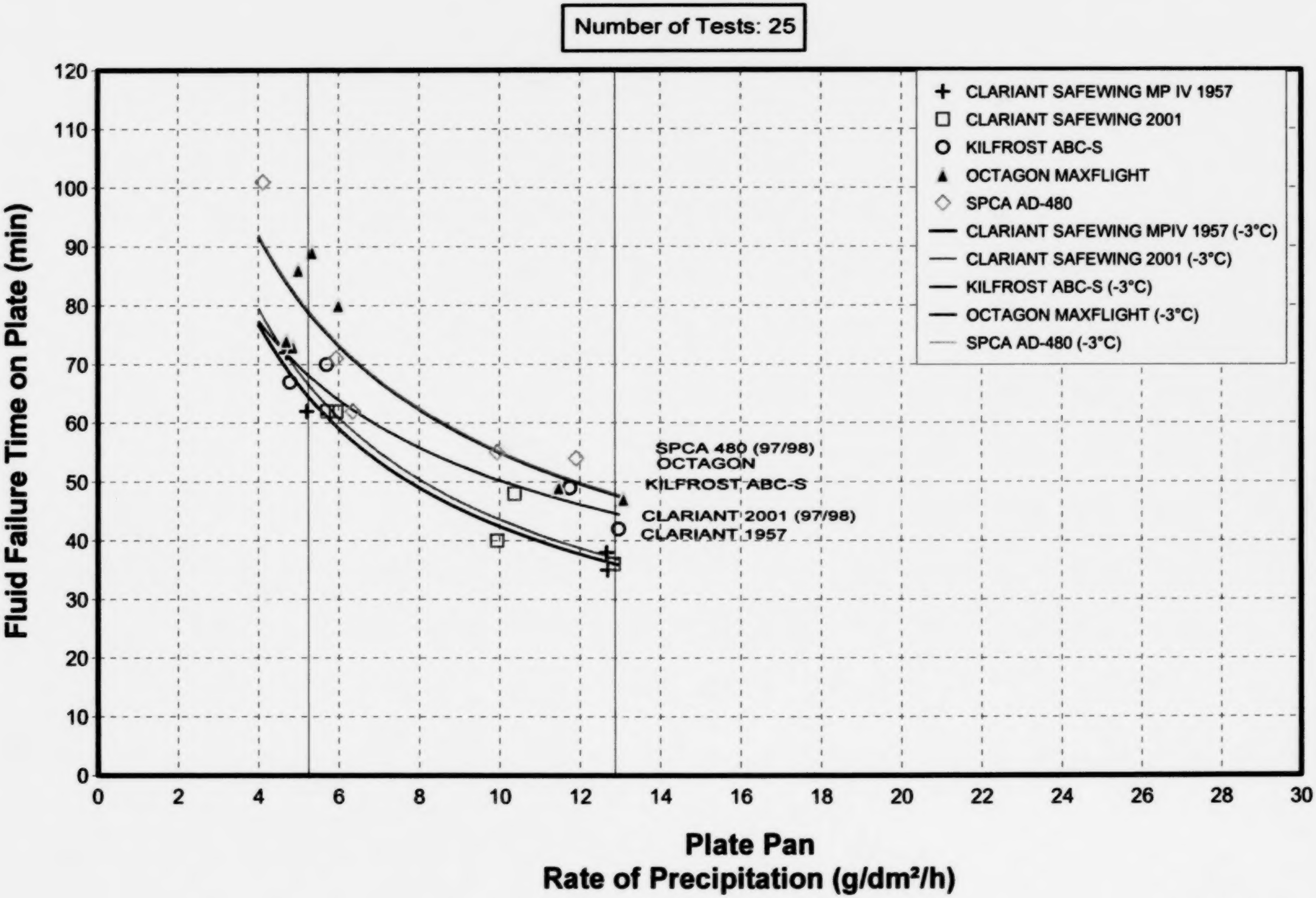
FIGURE 5.11

EFFECT OF FLUID BRAND AND RATE OF PRECIPITATION ON ENDURANCE TIME

TYPE IV 75/25

SIMULATED FREEZING DRIZZLE AT -3°C

1998-99



cm1514/report/hot_subs/ZD-3_47.GRF

All SAE holdover times remain unchanged in these two cells, and are based on the results of diluted Ultra+, which is not certified for use in diluted form. The fluid-specific holdover time values of each fluid tested in 1998-99 were reduced from the previous year.

iii. 50/50 fluid, above 0°C and 0°C to -3°C, freezing drizzle (Figure 5.12)

Freezing Drizzle Above 0°C, 0 to -3°C	**SAE**	**Oct Max**	**K-ABC-S**	**C-1957**	**H-1957**	**Ultra+ (do not use)**	**S-480**	**C-2001**	**S-404**
1996-97 Test Results and Tables used in 1997-98	0:10-0:20	0:55-1:40	0:15-0:25		0:20-0:35	0:10-0:20			
1997-98 Test Results		0:35-1:00	0:15-0:20	0:15-0:25			0:15-0:35	0:10-0:20	0:25-0:55
1998-99 Tables	0:10-0:20	0:35-1:00	0:15-0:20	0:15-0:25			0:15-0:35	0:10-0:20	0:25-0:55
1998-99 Test Results		0:15-0:25	0:15-0:20	0:15-0:25					
1999-2000 Tables	0:10-0:20	0:15-0:25	0:15-0:20	0:15-0:25			0:15-0:35	0:10-0:20	

The SAE holdover times for these two cells remain unchanged from last year and are based on the results of three different fluids. The fluid-specific values of all fluids in this cell are similar, with the exception of SPCA AD-480, which is slightly superior. The fluid-specific holdover times for Octagon Max-Flight were significantly decreased based on the results of the most recent testing with low-viscosity fluid samples.

FIGURE 5.12

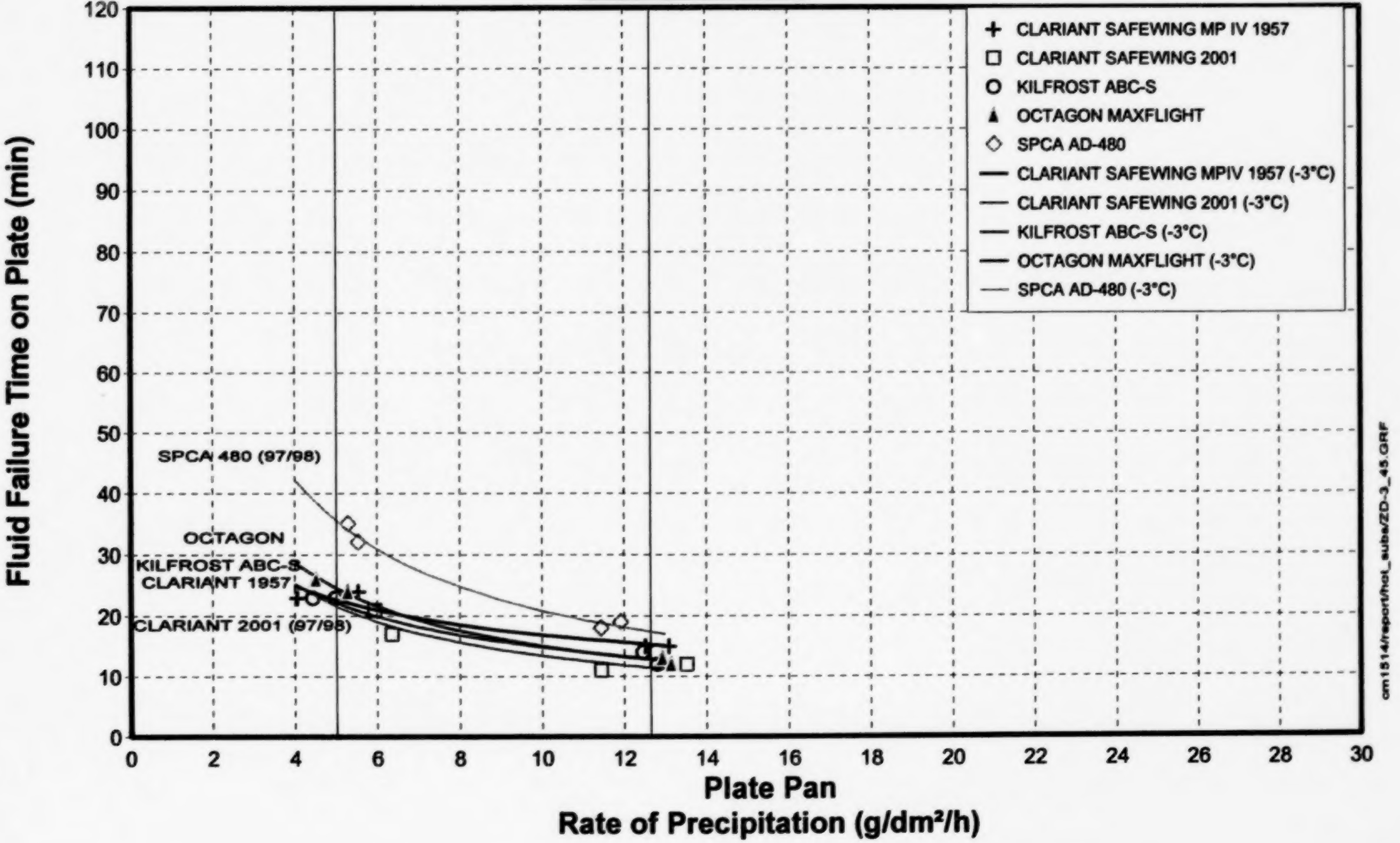
EFFECT OF FLUID BRAND AND RATE OF PRECIPITATION ON ENDURANCE TIME

TYPE IV 50/50

SIMULATED FREEZING DRIZZLE AT -3°C

1998-99

Number of Tests: 20



iv. Neat fluid, -3° C to -10°C, freezing drizzle (Figure 5.13)

Freezing Drizzle -3 to -10°C	SAE	Oct Max	K-ABC-S	C-1957	H-1957	Ultra+	S-480	C-2001	S-404
1996-97 Test Results and Tables used in 1997-98	0:30-1:00	0:30-1:10	0:35-1:00		0:40-1:00	0:50-1:35			
1997-98 Test Results		0:30-1:25	0:40-1:20	0:55-1:25			0:25-1:20	0:55-1:35	1:05-2:00
1998-99 Tables	0:25-1:00	0:30-1:10	0:35-1:00	0:55-1:25		0:50-1:35	0:25-1:20	0:55-1:35	1:05-2:00
1998-99 Test Results		0:25-1:15	0:20-1:30	0:35-0:55		0:45-1:25			
1999-2000 Tables	0:20-0:55	0:25-1:10	0:20-1:00	0:35-0:55		0:45-1:25	0:25-1:20	0:55-1:35	

The SAE lower and upper holdover time limits for neat fluid in this temperature range and precipitation type were reduced by 5 minutes from the previous SAE numbers. One fluid exhibits performance equal to the lower SAE number, while another fluid is responsible for the upper number. The fluid-specific values for every fluid tested were reduced from previous values.

v. 75/25 fluid, -3°C to -10°C, freezing drizzle (Figure 5.14)

Freezing Drizzle -3 to -10°C	SAE	Oct Max	K-ABC-S	C-1957	H-1957	Ultra+ (do not use)	S-480	C-2001	S-404
1996-97 Test Results and Tables used in 1997-98	0:30-1:00	0:30-1:05	0:50-1:25		0:40-1:05	0:30-1:00			
1997-98 Test Results		0:25-120	0:30-1:10	0:45-1:15			0:30-1:15	0:40-1:10	0:30-1:45
1998-99 Tables	0:25-1:00	0:25-1:05	0:30-1:10	0:45-1:15			0:30-1:15	0:40-1:10	0:30-1:45
1998-99 Test Results		0:20-1:00	0:20-1:30	0:25-0:55					
1999-2000 Tables	0:20-0:55	0:20-1:00	0:20-1:10	0:25-0:55			0:30-1:15	0:40-1:10	

FIGURE 5.13

EFFECT OF FLUID BRAND AND RATE OF PRECIPITATION ON ENDURANCE TIME

TYPE IV NEAT

SIMULATED FREEZING DRIZZLE AT -10°C

1998-99

Number of Tests: 35

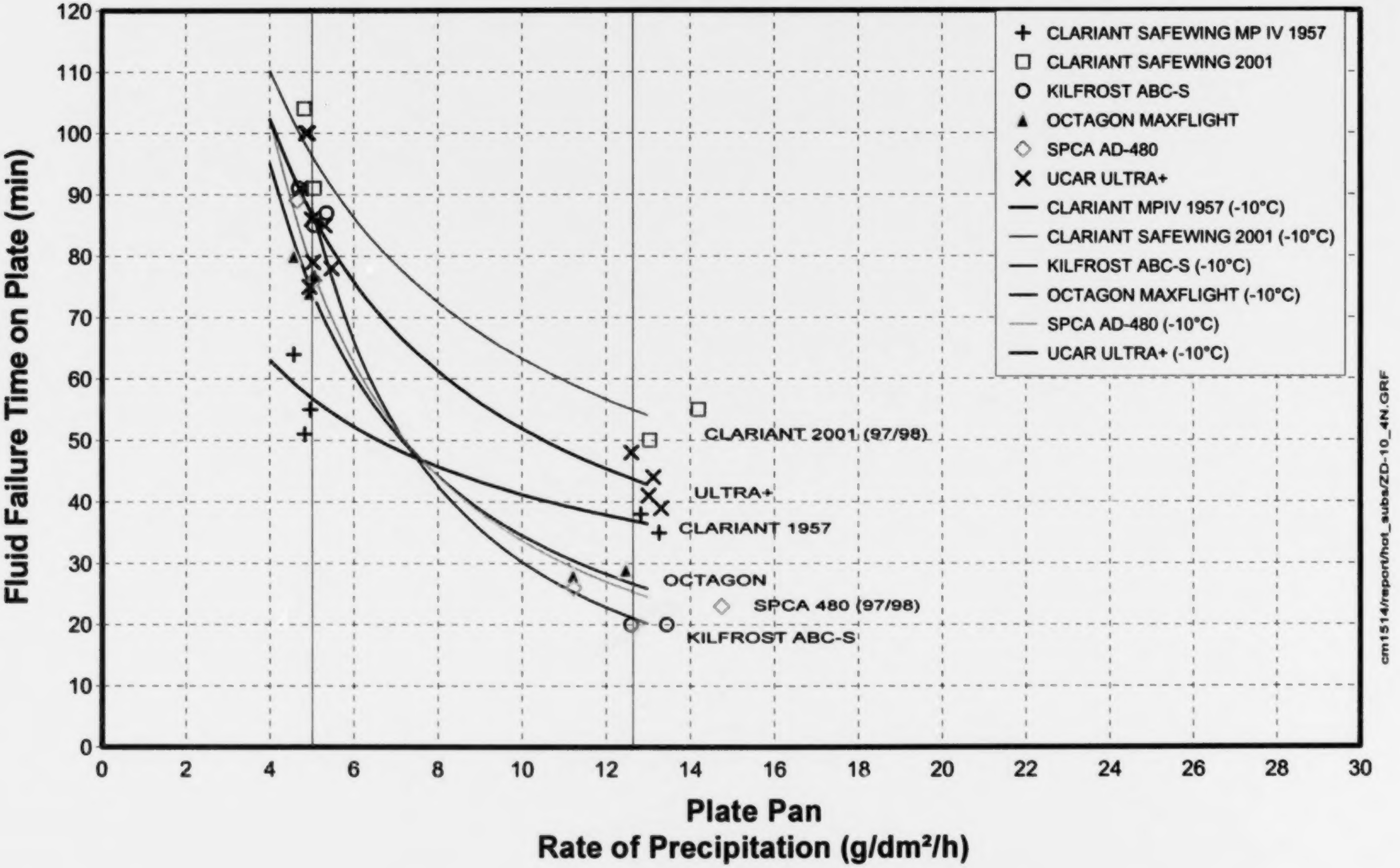


FIGURE 5.14

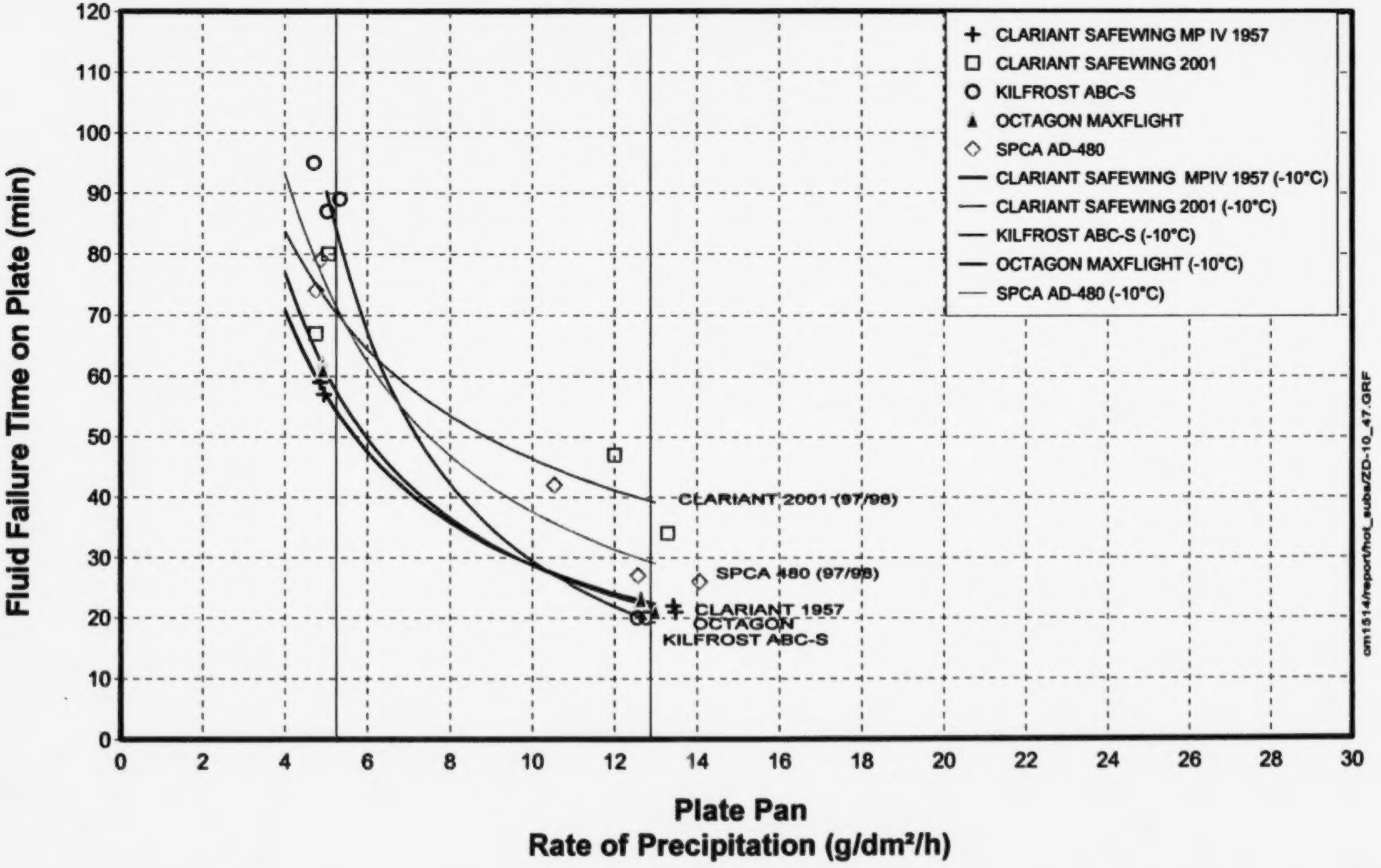
EFFECT OF FLUID BRAND AND RATE OF PRECIPITATION ON ENDURANCE TIME

TYPE IV 75/25

SIMULATED FREEZING DRIZZLE AT -10°C

1998-99

Number of Tests: 22



The SAE upper and lower holdover times for 75/25 fluid in freezing drizzle were reduced by five minutes based on the results of three fluids and match the SAE holdover times of neat fluid in the same temperature range. The fluid-specific holdover times of the three fluids tested were reduced from previous values.

5.2.3.2 Overall Perspective on Freezing Drizzle Results

Four changes were made to the SAE holdover time table in freezing drizzle. All changes occurred in the -3°C to -10°C temperature range. The upper and lower holdover times in the two cells were reduced by 5 minutes.

5.2.4 Light Freezing Rain

The following is a cell-by-cell summary of the holdover time performance of all Type IV fluid brands tested under conditions of simulated light freezing rain. The results are arranged in the sequence of temperature ranges (from top to bottom) that appear in the corresponding columns of the holdover time tables. Because it was not possible to simulate freezing rain above 0°C, the holdover time results for this category of precipitation above 0°C are identical to those in the range of 0°C to -3°C.

The first horizontal row of values in each of the following tables contains the SAE and fluid-specific holdover time values used in 1997-98, a result of tests conducted in 1996-97. The second line in each table contains the holdover time results from 1997-98 testing. The third line contains the SAE and fluid-specific holdover time results that were used in winter operations in 1998-99. The fourth set of values consists of the holdover time test results from 1998-99 testing. The final row in each table contains the SAE and fluid-specific holdover time values accepted for use in 1999-2000 winter operations. The underlined holdover time values in each of the tables indicate the fluid(s) responsible for the SAE holdover time.

The fluid failure time versus precipitation rate data for this category of precipitation are plotted either as a function of temperature or as a function of fluid brand. The plots as a function of fluid brand are used to help present discussions regarding changes to holdover times and appear in the body of the text as Figures 5.15 to 5.19.

5.2.4.1 Changes to Type IV Fluid Holdover Times for Light Freezing Rain

i. Neat fluid, above 0°C and 0 to -3°C, light freezing rain (Figure 5.15)

Light Freezing Rain Above 0°C, 0 to -3°C	SAE	Oct Max	K-ABC-S	C-1957	H-1957	Ultra+	S-480	C-2001	S-404
1996-97 Test Results and Tables used in 1997-98	0:35-0:55	0:40-1:15	1:00-1:25		0:40-0:55	0:35-1:00			
1997-98 Test Results		0:35-1:00	1:20-2:00	0:40-1:00			0:50-1:10	0:40-1:00	0:45-1:20
1998-99 Tables	0:35-0:55	0:35-1:00	1:00-1:25	0:40-1:00		0:35-1:00	0:50-1:10	0:40-1:00	0:45-1:20
1998-99 Test Results		0:30-0:50	1:20-2:00	0:30-0:45		0:25-0:40			
1999-2000 Tables	0:25-0:40	0:30-0:50	1:00-1:25	0:30-0:45		0:25-0:40	0:50-1:10	0:40-1:00	

Both the upper and lower holdover times in this cell have been reduced. One fluid is responsible for both decreases. The holdover time performances of the various fluids tested in 1998-99 vary greatly (see Figure 5.15). In general, the fluid-specific holdover times have decreased from those used in 1998-99 winter operations.

ii. 75/25 fluid, above 0°C and 0 to -3°C, light freezing rain (Figure 5.16)

Light Freezing Rain Above 0°C, 0 to -3°C	SAE	Oct Max	K-ABC-S	C-1957	H-1957	Ultra+ (do not use)	S-480	C-2001	S-404
1996-97 Test Results and Tables used in 1997-98	0:15-0:30	0:50-1:15	0:35-0:50		0:25-0:40	0:15-0:30			
1997-98 Test Results		0:35-1:10	0:40-0:55	0:30-0:40			0:35-0:50	0:25-0:35	0:30-0:50
1998-99 Tables	0:15-0:30	0:35-1:10	0:35-0:50	0:30-0:40			0:35-0:50	0:25-0:35	0:30-0:50
1998-99 Test Results		0:20-0:40	0:35-0:50	0:25-0:40					
1999-2000 Tables	0:15-0:30	0:20-0:40	0:35-0:50	0:25-0:40			0:35-0:50	0:25-0:35	

The SAE holdover times in these two cells have remained unchanged and are based on the results of the Ultra+ fluid tested in 1996-97.

FIGURE 5.15

EFFECT OF FLUID BRAND AND RATE OF PRECIPITATION ON ENDURANCE TIME

TYPE IV NEAT

SIMULATED LIGHT FREEZING RAIN AT -3°C

1998-99

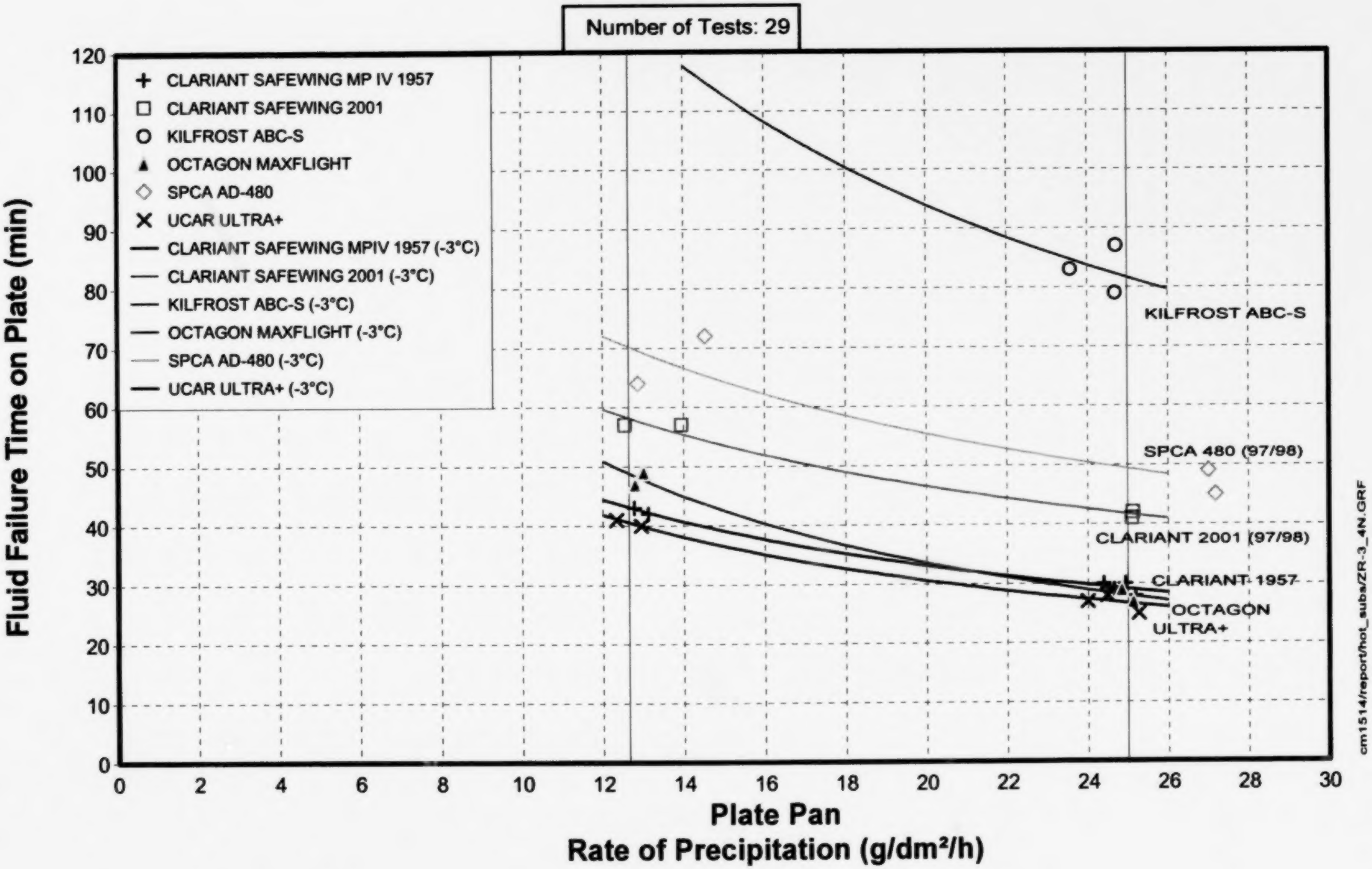


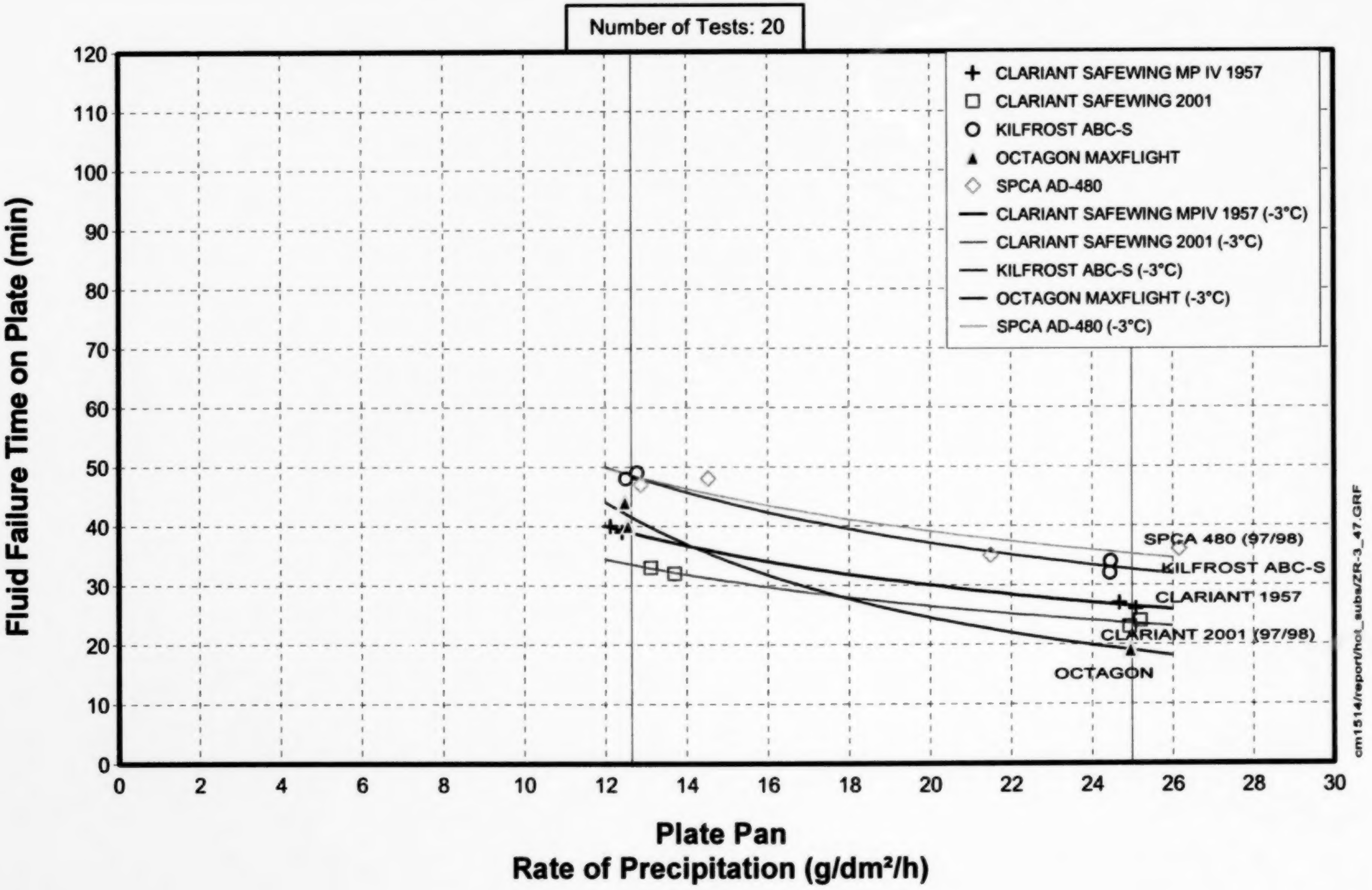
FIGURE 5.16

EFFECT OF FLUID BRAND AND RATE OF PRECIPITATION ON ENDURANCE TIME

TYPE IV 75/25

SIMULATED LIGHT FREEZING RAIN AT -3°C

1998-99



iii. 50/50 fluid, above 0°C and 0 to -3°C, light freezing rain (Figure 5.17)

Light Freezing Rain Above 0°C, 0 to -3°C	SAE	Oct Max	K-ABC-S	C-1957	H-1957	Ultra + (do not use)	S-480	C-2001	S-404
1996-97 Test Results and Tables used in 1997-98	0:05-0:10	0:30-0:55	0:10-0:15		0:15-0:20	0:05-0:10			
1997-98 Test Results	0:05-0:10	0:15-0:30	0:10-0:15	0:10--0:15			0:10-0:25	0:10-0:15	0:15-0:35
1998-99 Tables	0:05-0:10	0:15-0:30	0:10-0:15	0:10--0:15			0:10-0:25	0:10-0:15	0:15-0:35
1998-99 Test Results	0:05-0:10	0:05-0:15	0:05-0:10	0:05-0:15					
1999-2000 Tables	0:05-0:10	0:05-0:15	0:05-0:10	0:05-0:15			0:10-0:25	0:05-0:15	

The SAE values have not changed in these two cells. The results of three fluids tested during the past year equal those of the SAE numbers. The fluid-specific values of the three fluids tested in 1998-99 are similar but have been reduced from those values appearing in 1998-99 fluid-specific holdover time tables. The lower holdover time limit for Clariant 2001 was rounded down to 5 minutes.

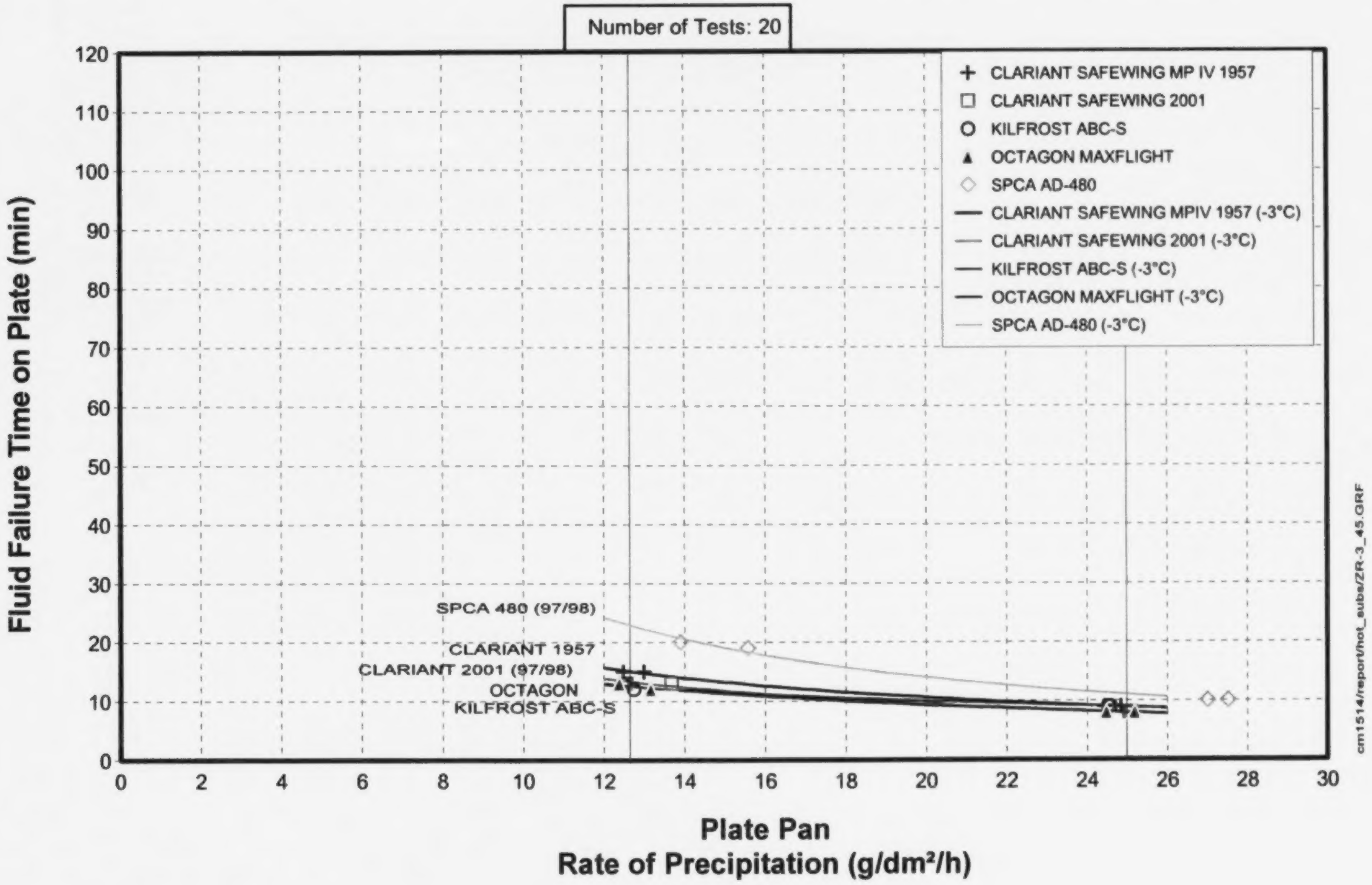
FIGURE 5.17

EFFECT OF FLUID BRAND AND RATE OF PRECIPITATION ON ENDURANCE TIME

TYPE IV 50/50

SIMULATED LIGHT FREEZING RAIN AT -3°C

1998-99



iv. Neat fluid, -3° C to -10°C, light freezing rain (Figure 5.18)

Light Freezing Rain -3 to -10°C	SAE	Oct Max	K-ABC-S	C-1957	H-1957	Ultra +	S-480	C-2001	S-404
1996-97 Test Results and Tables used in 1997-98	0:30-0:45	0:30-0:55	0:30-0:45		0:30-0:50	0:30-0:50			
1997-98 Test Results		0:20-0:40	0:20-0:40	0:30-0:45			0:20-0:40	0:30-0:45	0:35-1:20
1998-99 Tables	0:15-0:30	0:20-0:40	0:20-0:40	0:30-0:45		0:30-0:50	0:20-0:40	0:30-0:45	0:35-1:20
1998-99 Test Results		0:15-0:40	0:10-0:30	0:20-0:35		0:30-0:45			
1999-2000 Tables	0:10-0:30	0:15-0:40	0:10-0:30	0:20-0:35		0:30-0:45	0:20-0:40	0:30-0:45	

The SAE lower limit holdover time for neat fluid in this temperature range and precipitation type was reduced from the previous SAE numbers. In addition, all fluid-specific values were reduced from those used in 1998-99 winter operations.

v. 75/25 fluid, -3°C to -10°C, light freezing rain (Figure 5.19)

Light Freezing Rain -3 to -10°C	SAE	Oct Max	K-ABC-S	C-1957	H-1957	Ultra + (do not use)	S-480	C-2001	S-404
1996-97 Test Results and Tables used in 1997-98	0:15-0:30	0:25-0:35	0:35-0:50		0:25-0:40	0:15-0:30			
1997-98 Test Results		0:20-0:30	0:25-0:35	0:25-0:35			0:20-0:35	0:20-0:30	0:30-0:45
1998-99 Tables	0:15-0:30	0:20-0:30	0:25-0:35	0:25-0:35			0:20-0:35	0:20-0:30	0:30-0:45
1998-99 Test Results		0:15-0:30	0:10-0:35	0:15-0:30					
1999-2000 Tables	0:10-0:30	0:15-0:30	0:10-0:35	0:15-0:30			0:20-0:35	0:20-0:30	

The lower SAE holdover time in this cell was reduced by 5 minutes, based on the result of one fluid. Several fluids exhibit holdover time performance equal to that of the upper SAE value. The SAE holdover times in this cell are identical to those of neat fluid in this temperature range. In addition, all fluid-specific values were reduced from those used in 1998-99 winter operations.

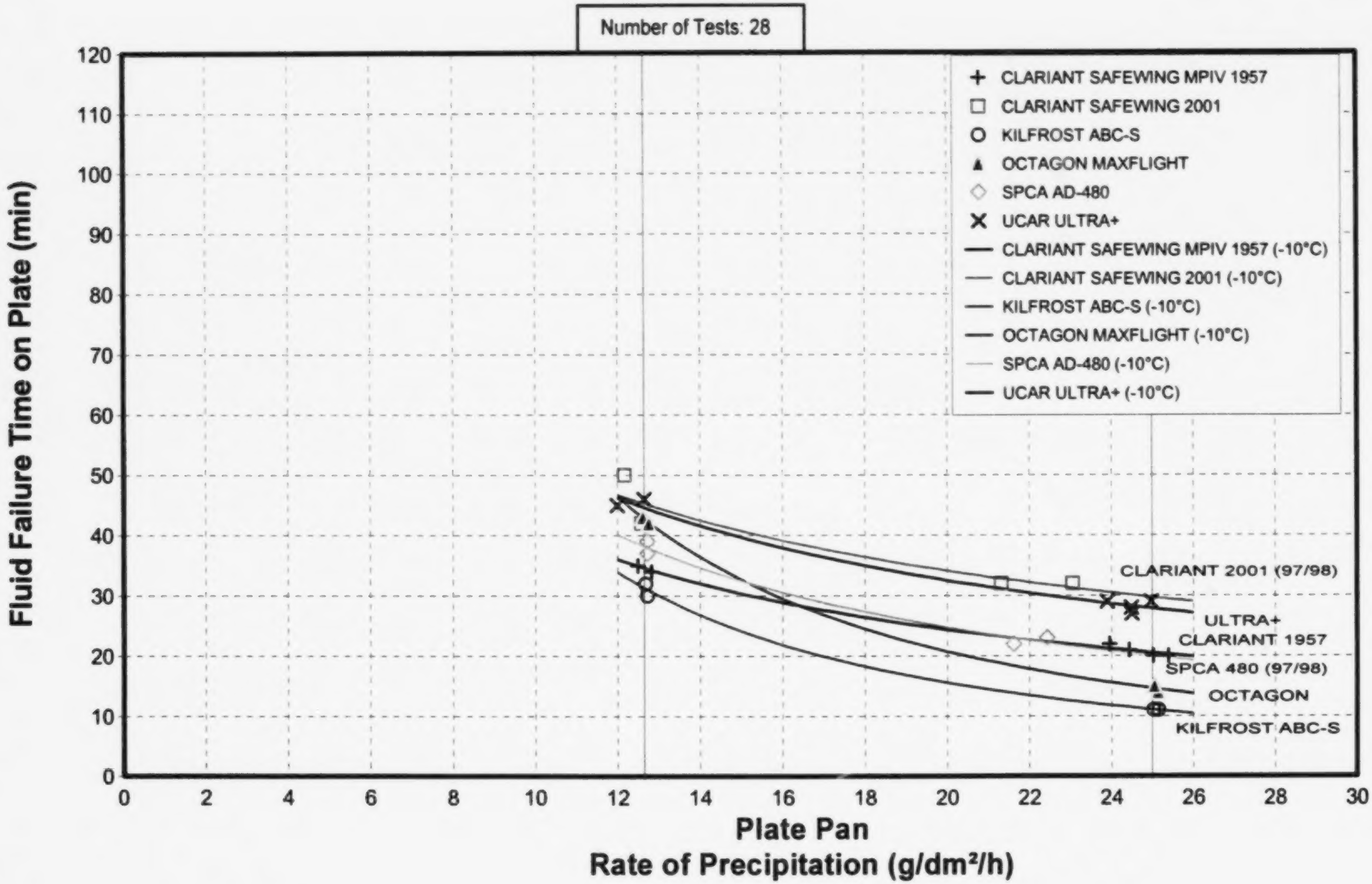
FIGURE 5.18

EFFECT OF FLUID BRAND AND RATE OF PRECIPITATION ON ENDURANCE TIME

TYPE IV NEAT

SIMULATED LIGHT FREEZING RAIN AT -10°C

1998-99



cm1514/report/hot_subs/ZR-10_4N.GRF

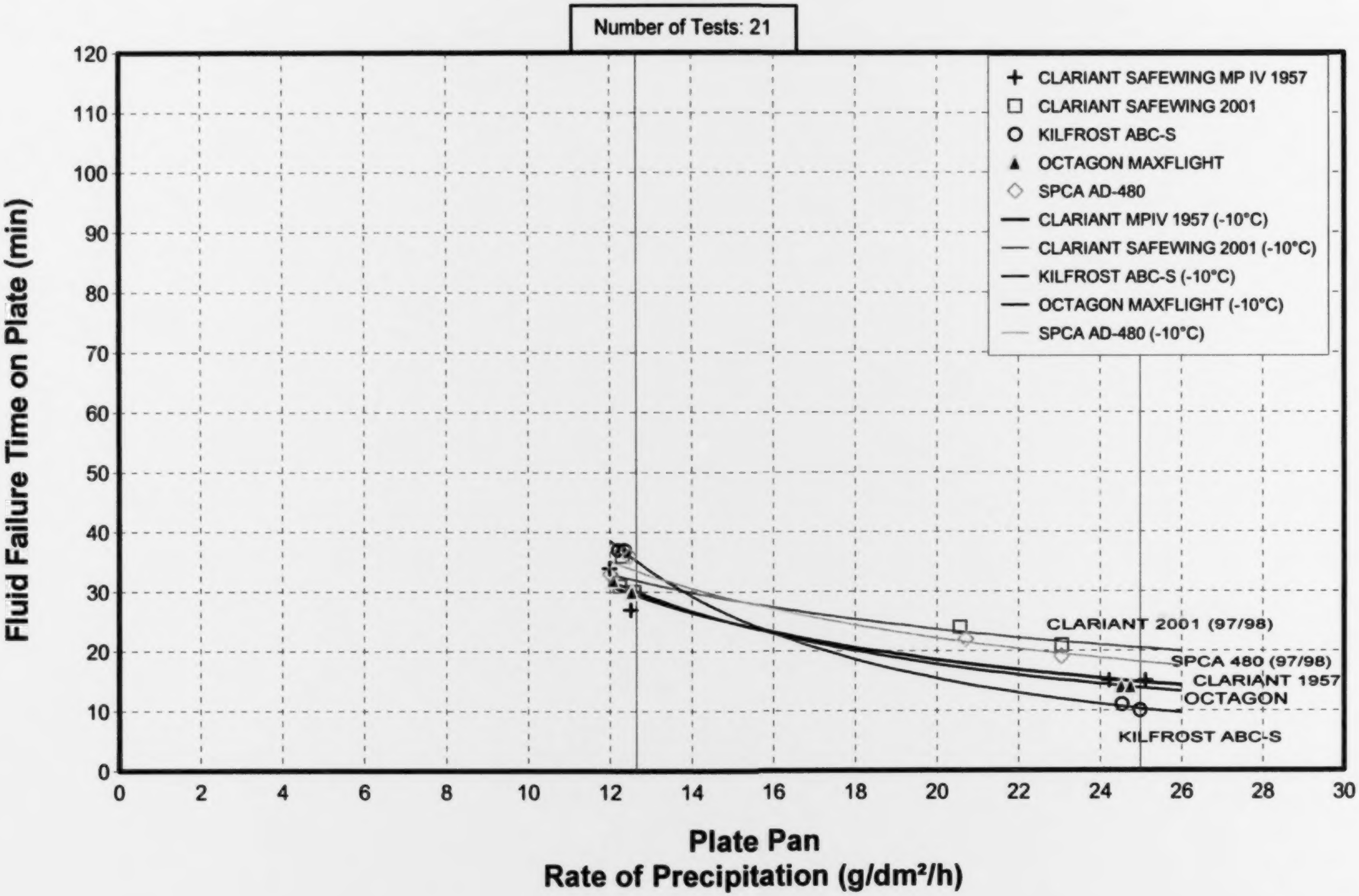
FIGURE 5.19

EFFECT OF FLUID BRAND AND RATE OF PRECIPITATION ON ENDURANCE TIME

TYPE IV 75/25

SIMULATED LIGHT FREEZING RAIN AT -10°C

1998-99



cm1514/report/hot_subs/ZR-10_47.GRF

5.2.4.2 Overall Perspective on Light Freezing Rain Results

Six changes were made to the light freezing rain column of the SAE Type IV holdover time table. The lower limits of both -3°C to -10°C cells were reduced by five minutes. Reductions also occurred in both the upper and lower limits of the above 0°C and 0°C to -3°C cells.

5.2.5 Freezing Fog

The freezing fog category is divided into nine cells. The data were collected under precipitation rates of 2 and 5 g/dm^2/h. From these data, lower holdover times for each cell were determined at 5 g/dm^2/h. In 1997-98, the upper holdover times were to be determined by tests conducted at 2 g/dm^2/h; however, it was felt in Vienna that this rate limit was not indicative of low rate natural fog. As a result, the upper holdover times in each of the fog cells were left untouched last year. The lower rate limit of 2 g/dm^2/h has since been re-established as the lower precipitation rate limit for freezing fog. Data from this year's testing are presented in Figures 5.20 to 5.25.

Failure times were measured at three different temperatures, -3°C, -14°C, and -25°C. Due to the inability to produce freezing fog at temperatures above 0°C, the holdover times for the temperature range above 0°C are identical to those in the range from 0 to -3°C.

This category of precipitation is one for which fluid-specific values were not adopted by the SAE G-12 Holdover Time Subcommittee in previous years. It was decided at the Toronto SAE meeting that fluid-specific holdover times for fog would be adopted this year based on the results of tests conducted during 1998-99 only, since this was the first year that tests were conducted at both rate limits. Any certified fluid that was not re-tested during the past year will obtain the SAE generic numbers for freezing fog. The fluid-specific holdover times from 1996-97 and 1997-98 testing have not been included.

5.2.5.1 Changes to Type IV Fluid Holdover Times for Freezing Fog

i. Neat fluid, above 0°C and 0° to -3°C, freezing fog (Figure 5.20)

Freezing Fog Above 0°C, 0 to -3°C	SAE	Oct Max	K-ABC-S	C-1957	H-1957	Ultra +	S-480	C-2001	S-404
1996-97 Test Results and Tables used in 1997-98	2:20-3:00								
1997-98 Test Results									
1998-99 Tables	2:00-3:00								
1998-99 Test Results		2:15-4:00	2:35-4:00	1:05-2:15		1:35-3:35			
1999-2000 Tables	1:05-2:15	2:15-4:00	2:35-4:00	1:05-2:15		1:35-3:35	1:05-2:15	1:05-2:15	

The current holdover time limits were reduced substantially, based on the results of the Clariant MPIV 1957 fluid. A wide variation exists in the holdover performances off the fluids tested in 1998-99. The upper fluid-specific values for Kilfrost and Octagon fluids were capped at four hours. Because the Clariant 2001 and SPCA AD-480 products were not re-tested during the past year, both fluids received the generic holdover times for freezing fog.

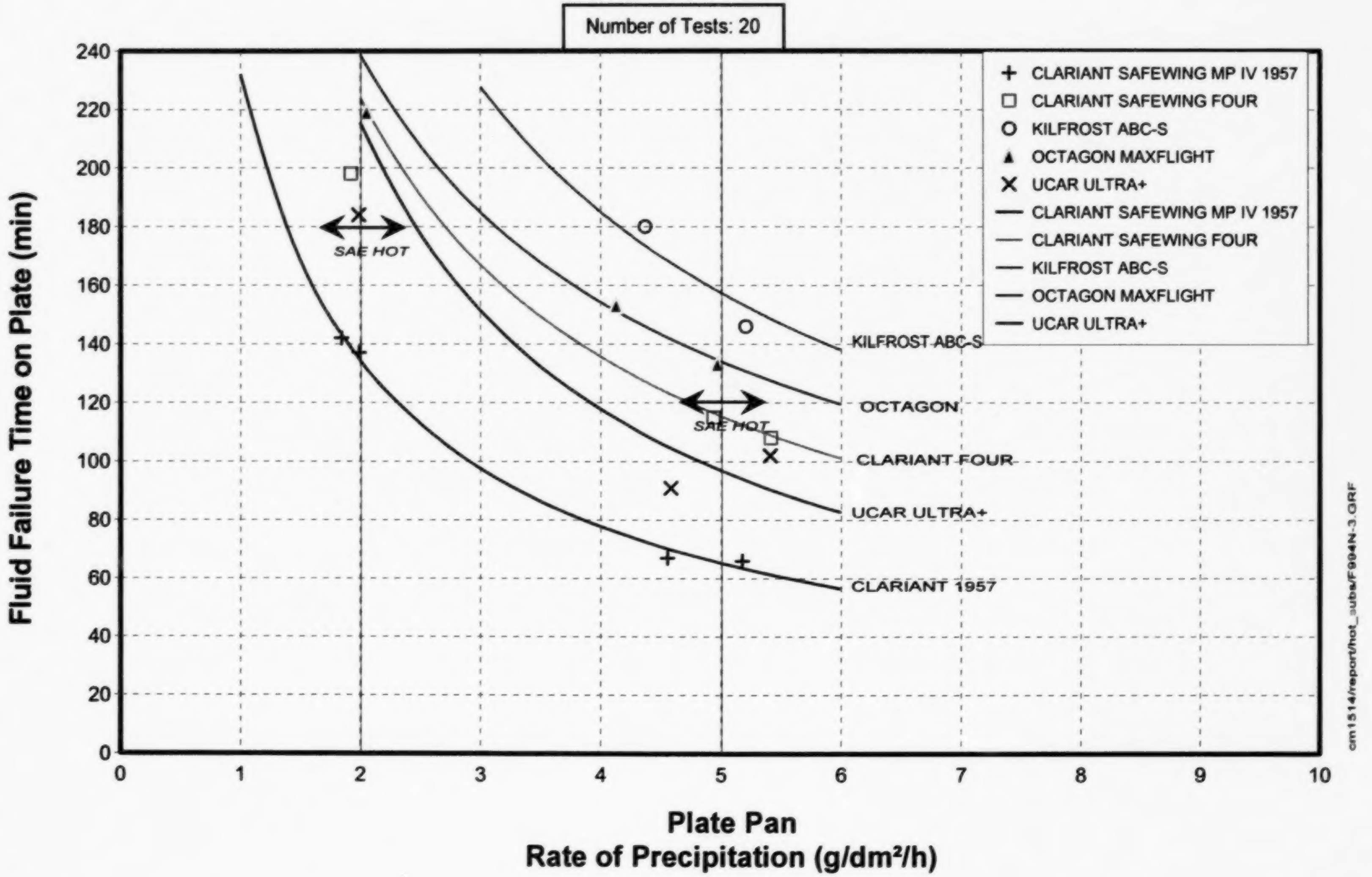
FIGURE 5.20

EFFECT OF FLUID BRAND AND RATE OF PRECIPITATION ON ENDURANCE TIME

TYPE IV NEAT

SIMULATED FREEZING FOG AT -3°C

1998-99



ii. 75/25 fluid, above 0°C and 0 to -3°C, freezing fog (Figure 5.21)

Freezing Fog Above 0°C, 0 to -3°C	SAE	Oct Max	K-ABC-S	C-1957	H-1957	Ultra + (do not use)	S-480	C-2001	S-404
1996-97 Test Results and Tables used in 1997-98	1:05-2:00								
1997-98 Test Results									
1998-99 Tables	1:05-2:00								
1998-99 Test Results		1:30-2:50	1:05-1:45	1:10-2:10					
1999-2000 Tables	1:05-1:45	1:30-2:50	1:05-1:45	1:10-2:10			1:05-1:45	1:05-1:45	

The upper SAE holdover times for fluids in these cells are driven by the result of one fluid from holdover time tests conducted during the past year. The lower SAE value has remained unchanged since 1996-97. With the exception of one fluid, the fluid holdover time performances of the fluids tested in 1998-99 were similar. Because the SPCA AD-480 and Clariant 2001 products were not re-tested in 1998-99, the fluid-specific values for these fluids match the SAE values.

iii. 50/50 fluid, above 0°C and 0 to -3°C, freezing fog (Figure 5.22)

Freezing Fog Above 0°C, 0 to -3°C	SAE	Oct Max	K-ABC-S	C-1957	H-1957	Ultra + (do not use)	S-480	C-2001	S-404
1996-97 Test Results and Tables used in 1997-98	0:20-0:45								
1997-98 Test Results									
1998-99 Tables	0:20-0:45								
1998-99 Test Results		0:30-0:50	0:20-0:35	0:25-0:50					
1999-2000 Tables	0:20-0:35	0:30-0:50	0:20-0:35	0:25-0:50			0:20-0:35	0:20-0:35	

FIGURE 5.21

EFFECT OF FLUID BRAND AND RATE OF PRECIPITATION ON ENDURANCE TIME

TYPE IV 75/25

SIMULATED FREEZING FOG AT -3°C
1998-99

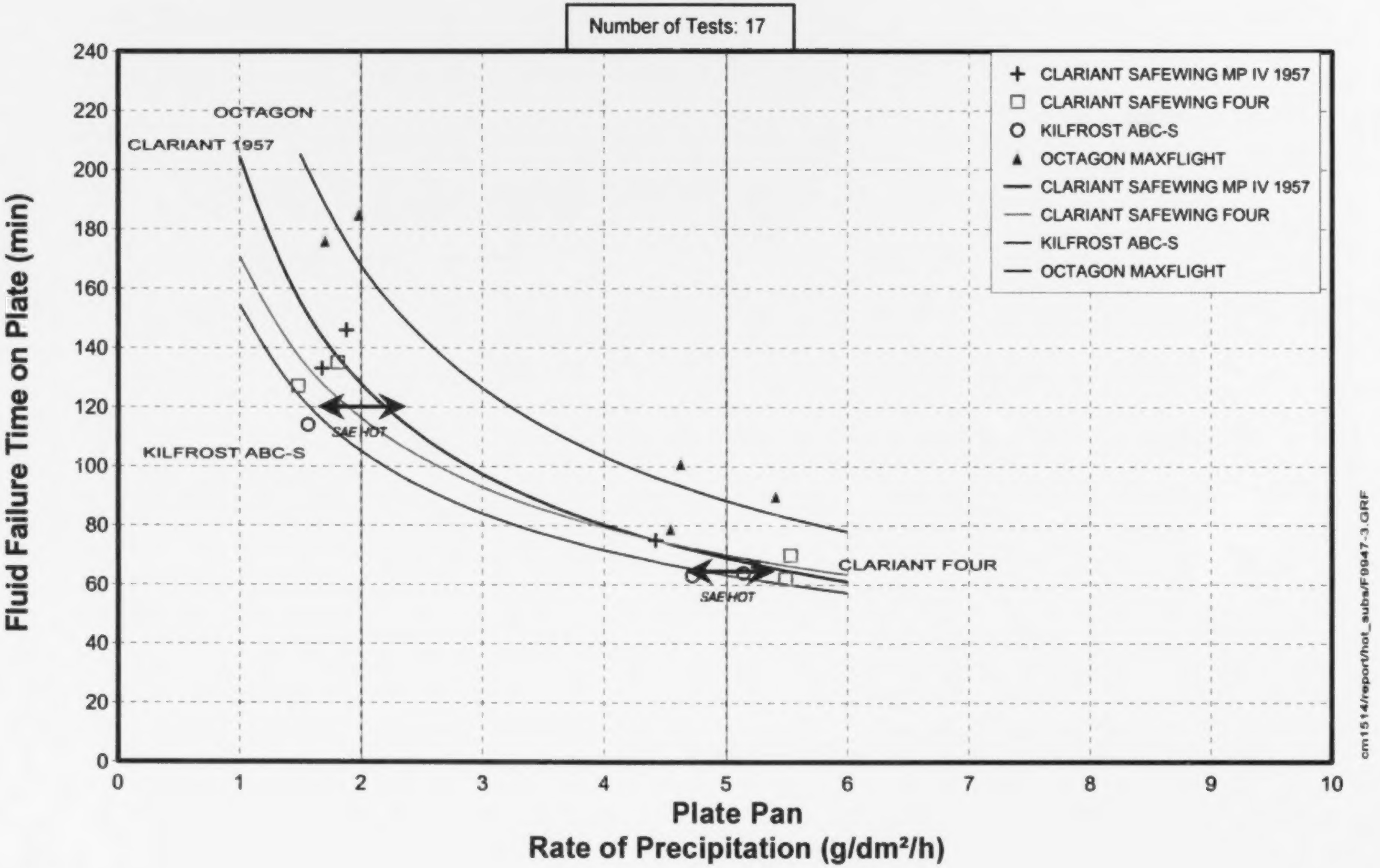
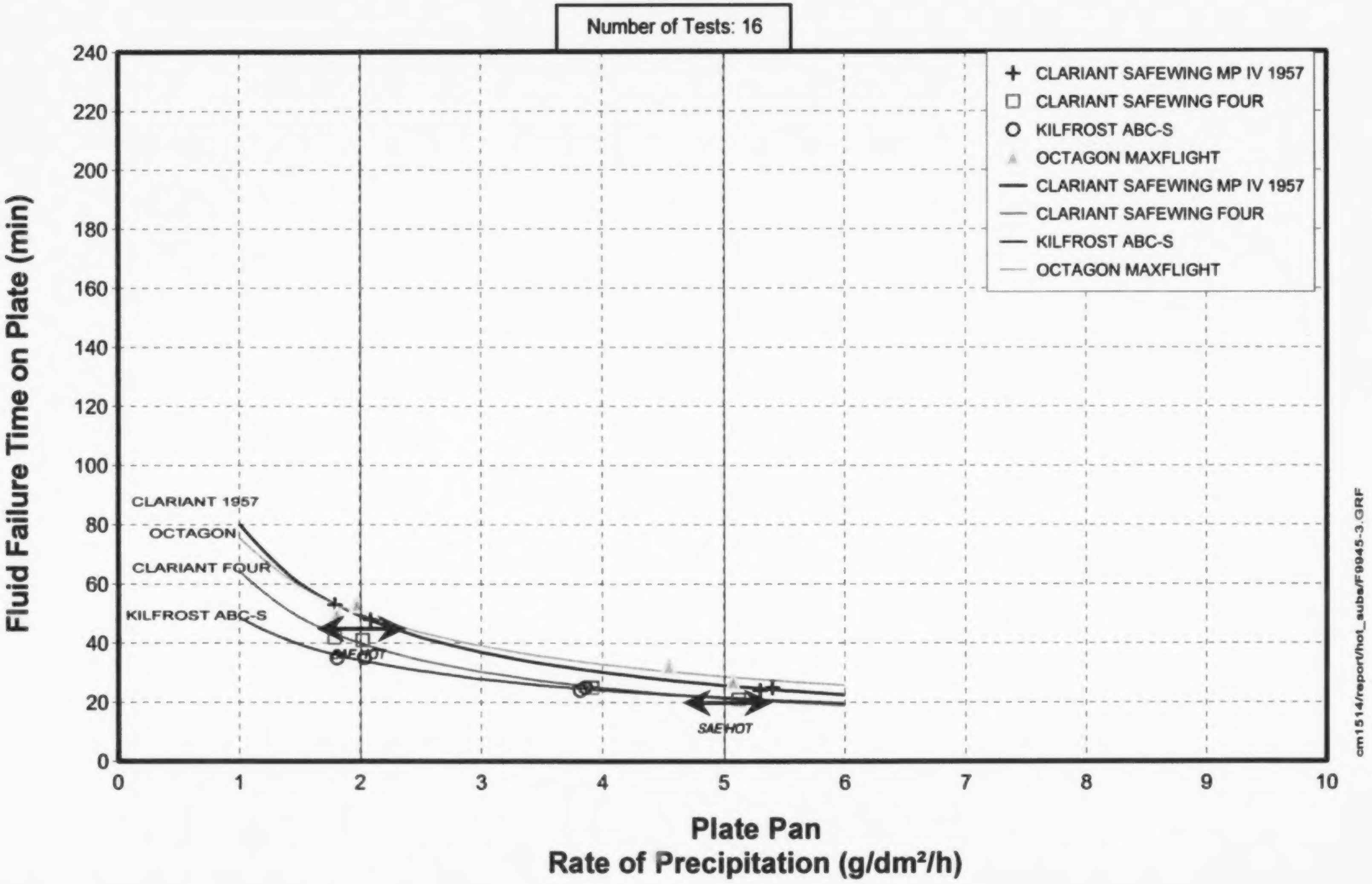


FIGURE 5.22
EFFECT OF FLUID BRAND AND RATE OF PRECIPITATION ON ENDURANCE TIME
TYPE IV 50/50
SIMULATED FREEZING FOG AT -3°C
1998-99



The upper SAE holdover times for fluids in these cells were reduced by 10 minutes from last year. The lower SAE number has remained unchanged since 1996-97. One fluid is responsible for the SAE values. Because the SPCA AD-480 and Clariant 2001 products were not re-tested in 1998-99, the fluid-specific values for these fluids match the SAE values.

iv. Neat fluid, -3 to -14°C, freezing fog (Figure 5.23)

Freezing Fog -3 to -14°C	SAE	Oct Max	K-ABC-S	C-1957	H-1957	Ultra+	S-480	C-2001	S-404
1996-97 Test Results and Tables used in 1997-98	0:40-3:00								
1997-98 Test Results									
1998-99 Tables	0:40-3:00								
1998-99 Test Results		0:45-1:55	0:45-2:05	0:45-1:30		1:25-3:00			
1999-2000 Tables	0:40-1:30	0:45-1:55	0:45-2:05	0:45-1:30		1:25-3:00	0:40-1:30	0:40-1:30	

The upper SAE holdover time for fluids in this cell was once again reduced based on the results of tests conducted at 2 $g/dm^2/h$. It is noteworthy that all four fluids tested during the past year have upper holdover times equal to or inferior to the SAE upper holdover time value for 1998-99. Because the SPCA AD-480 and Clariant 2001 products were not re-tested in 1998-99, the fluid-specific values for these fluids match the SAE values.

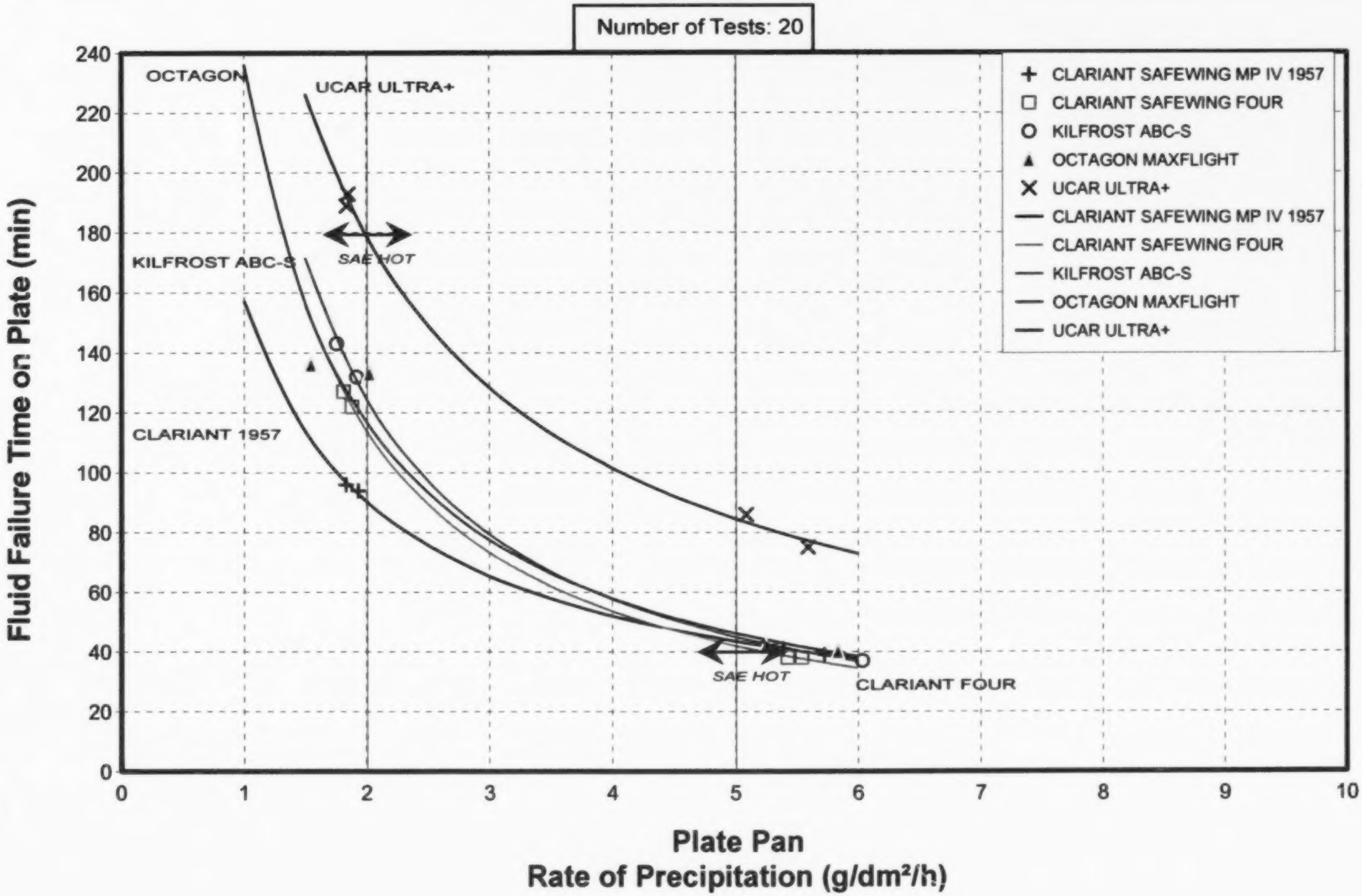
FIGURE 5.23

EFFECT OF FLUID BRAND AND RATE OF PRECIPITATION ON ENDURANCE TIME

TYPE IV NEAT

SIMULATED FREEZING FOG AT -14°C

1998-99



cm1514/report/hot_subs/F994N-14.GRF

v. 75/25 fluid, -3 to -14°C, freezing fog (Figure 5.24)

Freezing Fog -3 to -14°C	SAE	Oct Max	K-ABC-S	C-1957	H-1957	Ultra + (do not use)	S-480	C-2001	S-404
1996-97 Test Results and Tables used in 1997-98	0:35-2:00								
1997-98 Test Results									
1998-99 Tables	0:30-2:00								
1998-99 Test Results		0:30-1:10	0:25-1:00	0:25-1:10					
1999-2000 Tables	0:25-1:00	0:30-1:10	0:25-1:00	0:25-1:10			0:25-1:00	0:25-1:00	

The upper and lower SAE holdover times in this cell were reduced. While the lower SAE value decreased by 5 minutes, the upper SAE value was reduced by one half. All fluids tested during the past year display similar holdover time performance. Because the SPCA AD-480 and Clariant 2001 products were not re-tested in 1998-99, the fluid-specific values for these fluids match the SAE values.

vi. Neat fluid, -14° to -25°C, freezing fog (Figure 5.25)

Freezing Fog -3 to -14°C	SAE	Oct Max	K-ABC-S	C-1957	H-1957	Ultra +	S-480	C-2001	S-404
1996-97 Test Results and Tables used in 1997-98	0:20-2:00								
1997-98 Test Results									
1998-99 Tables	0:20-2:00								
1998-99 Test Results		0:20-0:40	0:20-0:40	0:25-0:40		0:40-2:10			
1999-2000 Tables	0:20-0:40	0:20-0:40	0:20-0:40	0:25-0:40		0:40-2:10	0:20-0:40	0:20-0:40	

FIGURE 5.24

EFFECT OF FLUID BRAND AND RATE OF PRECIPITATION ON ENDURANCE TIME

TYPE IV 75/25

SIMULATED FREEZING FOG AT -14°C

1998-99

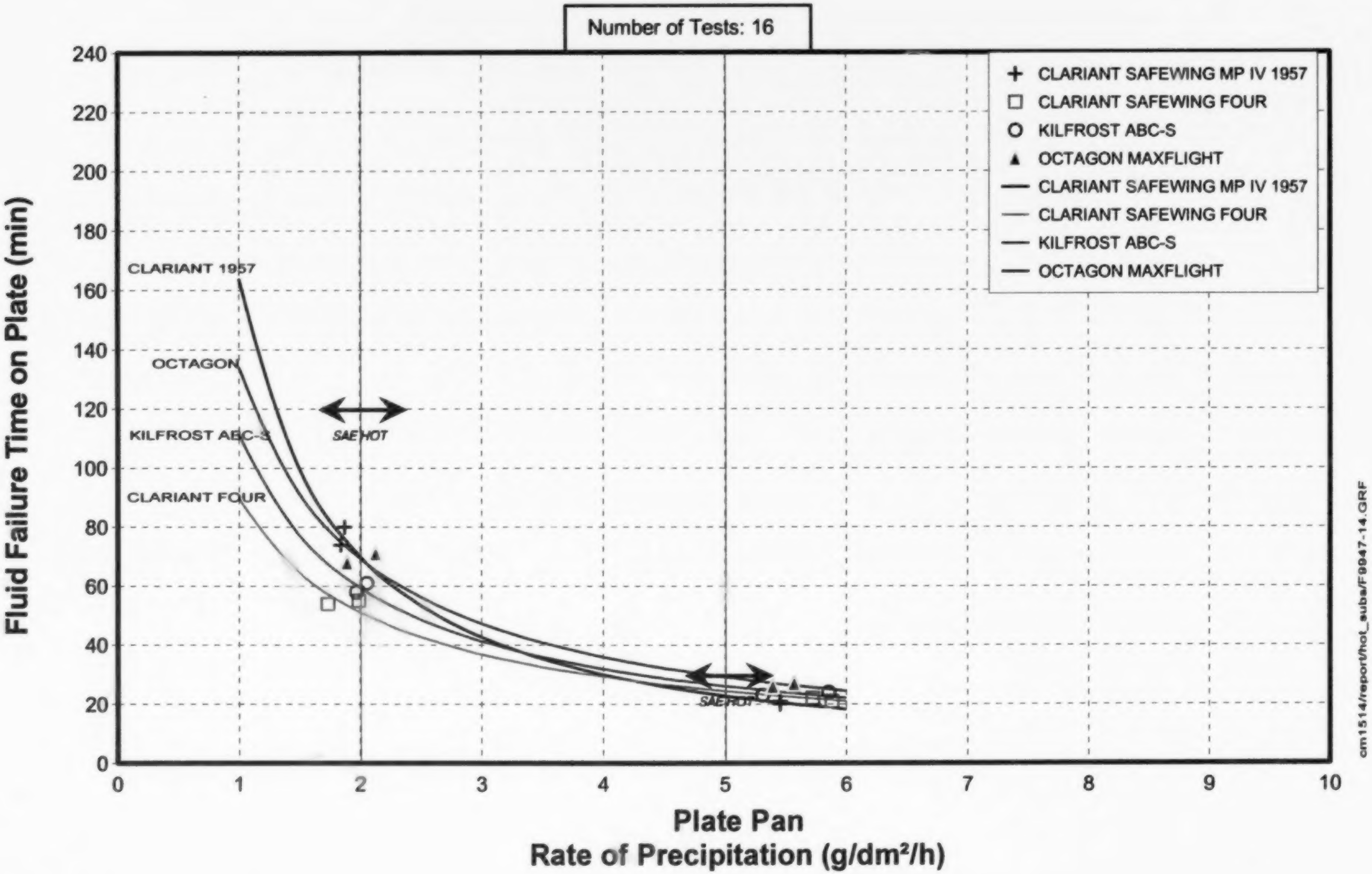


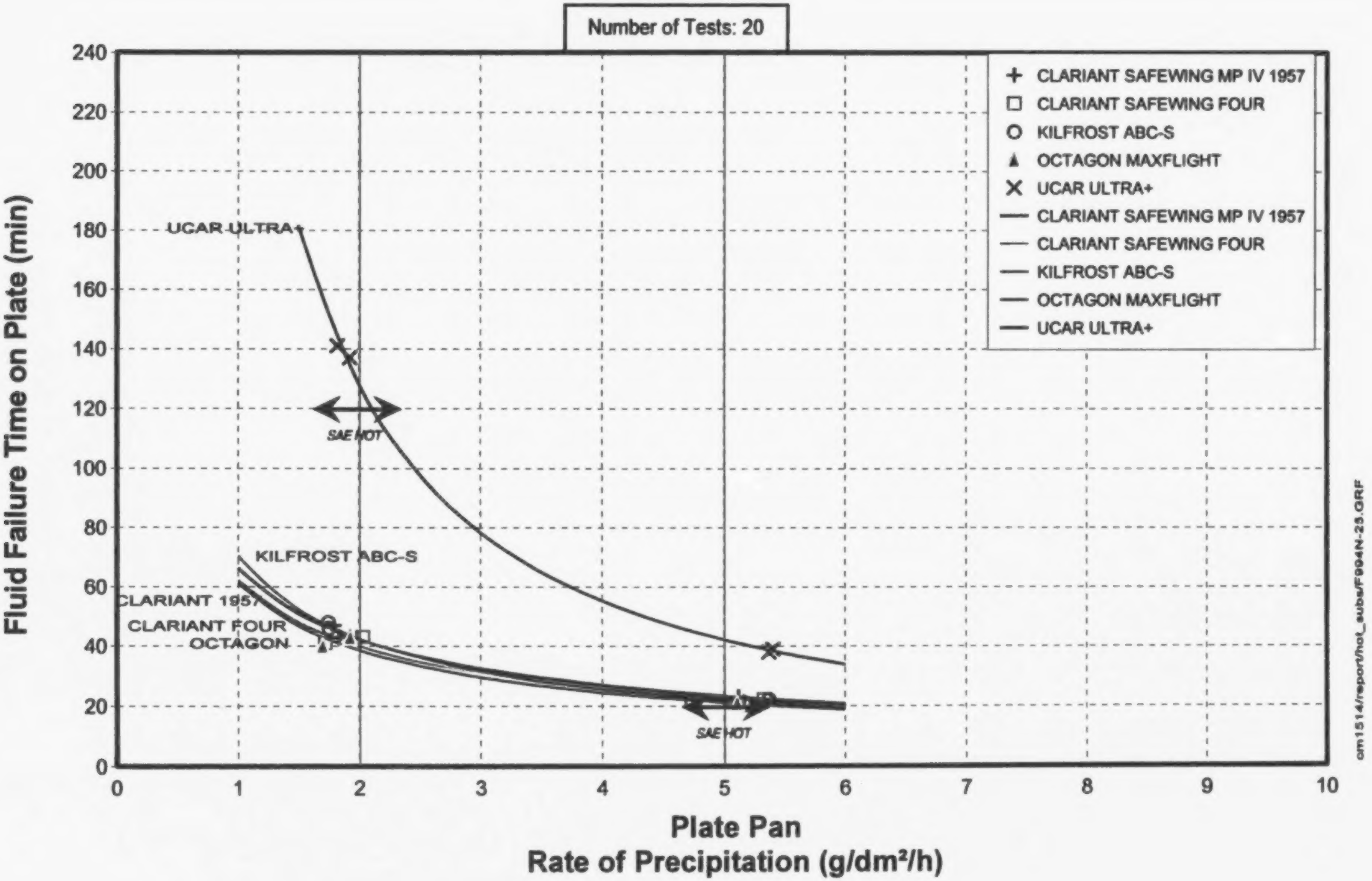
FIGURE 5.25

EFFECT OF FLUID BRAND AND RATE OF PRECIPITATION ON ENDURANCE TIME

TYPE IV NEAT

SIMULATED FREEZING FOG AT -25°C

1998-99



am1514/report/hot_subs/F994N-25.GRF

The upper SAE holdover time for fluids in this cell was reduced substantially over that of last year, from 2 hours to 40 minutes. While the three propylene fluids tested this year display similar holdover time performance in this cell, Ultra+ greatly outperforms the rest at this low temperature. This is likely due to the ease with which the fluid is diluted relative to the propylene-based fluids at this temperature. This tends to enhance the fluid's tendency to flow and shed accumulated solid contamination. Because the SPCA AD-480 and Clariant 2001 products were not re-tested in 1998-99, the fluid-specific values for these fluids match the SAE values.

5.2.5.2 Overall Perspective on Freezing Fog Results

Twelve changes were made to the freezing fog column of the SAE Type IV fluid holdover time table for the upcoming year. Nine of the changes occur in the upper holdover times, as tests were conducted for the first time at a rate of 2 g/dm^2/h. The majority of the changes to the upper holdover times were significant.

5.2.6 Rain on a Cold-Soaked Wing

The data used to evaluate the holdover times for this category of precipitation covered precipitation rates ranging from 5 g/dm^2/h to 76 g/dm2/h. This encompasses heavy drizzle (5 to 12.7 g/dm^2/h), light rain (12.7 to 25 g/dm^2/h), and moderate rain (25 to 76 g/dm^2/h). The cold-soak test boxes were 7.5 cm deep. Dimensional details are described in Section 2. The box temperature prior to the start of testing was -10°C.

The data are plotted for two Type IV fluid concentrations: neat fluid and 75/25 fluid. In past years, this category of precipitation is not one for which fluid-specific holdover times have been adopted by the SAE G-12 Holdover Time Subcommittee. At the SAE meetings in Toronto, it was decided that fluid-specific numbers would be included in the 1999-2000 holdover time tables.

5.2.6.1 Changes to Type IV Fluid Holdover Times for Rain on a Cold-Soaked Wing

i. Neat fluid, above 0°C, rain on a cold-soaked wing (Figure 5.26)

Rain on a cold-soaked wing Above 0°C	SAE	Oct Max	K-ABC-S	C-1957	H-1957	Ultra+	S-480	C-2001	S-404
1996-97 Test Results and Tables used in 1997-98	0:10-0:50								
1997-98 Test Results		0:15-1:15	0:20-1:15	0:15-1:20					
1998-99 Tables	0:10-0:50								
1998-99 Test Results		0:10-2:00	0:30-2:00	0:15-1:10		0:10-1:20			
1999-2000 Tables	0:10-0:50	0:10-2:00	0:20-1:15	0:15-1:10		0:10-1:20	0:10-0:50	0:10-0:50	

Although the holdover times in this cell remain unchanged from last year, two fluids tested during the past year display holdover time performance equal to that of the lower SAE holdover time. The upper SAE holdover time is once again driven by the results of past testing. Because the SPCA AD-480 and Clariant 2001 products were not re-tested in 1998-99, the fluid-specific values for these fluids match the SAE values.

ii. 75/25 fluid, above 0°C, rain on a cold-soaked wing (Figure 5.27)

Rain on a cold-soaked wing Above 0°C	SAE	Oct Max	K-ABC-S	C-1957	H-1957	Ultra+	S-480	C-2001	S-404
1996-97 Test Results and Tables used in 1997-98	0:05-0:35								
1997-98 Test Results		0:10-0:40	0:10-0:50	0:10-1:00					
1998-99 Tables	0:05-0:35								
1998-99 Test Results		0:05-1:15	0:10-1:15	0:10-1:05					
1999-2000 Tables	0:05-0:35	0:05-0:40	0:10-0:50	0:10-1:00			0:05-0:35	0:05-0:35	

FIGURE 5.26

EFFECT OF FLUID BRAND AND RATE OF PRECIPITATION ON ENDURANCE TIME

TYPE IV NEAT

RAIN ON COLD-SOAKED SURFACE

1998-99

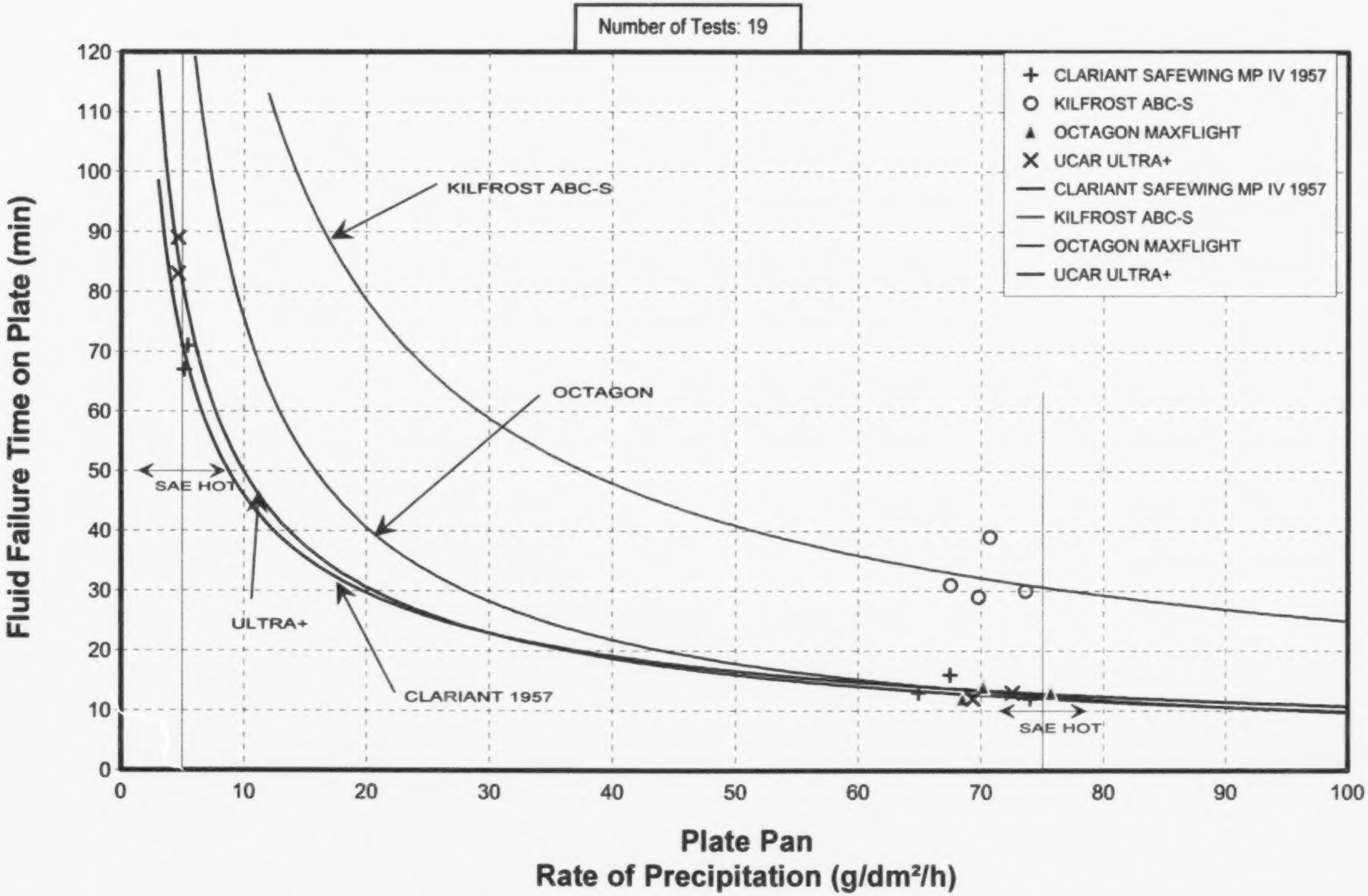


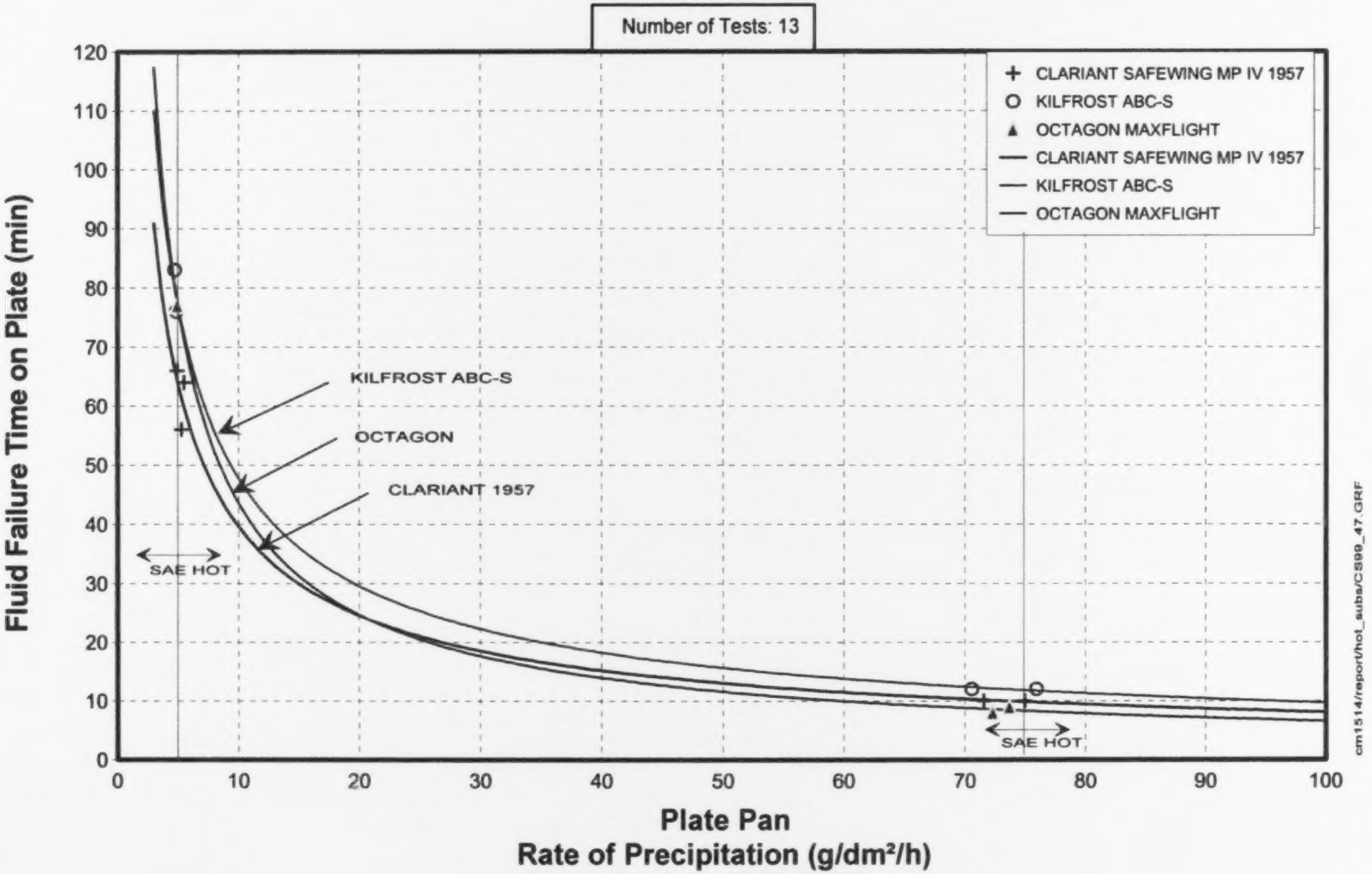
FIGURE 5.27

EFFECT OF FLUID BRAND AND RATE OF PRECIPITATION ON ENDURANCE TIME

TYPE IV 75/25

RAIN ON COLD-SOAKED SURFACE

1998-99



For this concentration, the regression curves obtained from the data plotted in this Figure 5.27 are tightly grouped at the 5 g/dm^2/h and 76 g/dm^2/h precipitation rate limits. One fluid tested in 1998-99 displays performance equal to the lower SAE holdover time. The numbers remain unchanged from last year. Because the SPCA AD-480 and Clariant 2001 products were not re-tested in 1998-99, the fluid-specific values for these fluids match the SAE values.

5.2.6.2 Overall Perspective on Rain on a Cold-Soaked Wing Results

No changes were made to the SAE holdover times in the rain on a cold-soaked wing condition. The data plotted in both Figures 5.26 and 5.27 show a tight grouping of regression curves at the higher precipitation rate limit (with the exception of the Kilfrost ABC-S Neat) and provide confidence for the lower holdover time values adopted in each cell of this category.

5.2.7 Worst-Case Fluids

The fluid(s) responsible for the values in each cell of the generic Type IV fluid holdover time table, along with the year that the fluid was tested, are shown in Table 5.3. Several of the holdover times are driven by fluids that are no longer commercially available, such as Hoechst MPIV 1957, SPCA AD-404 and diluted forms of Union Carbide Ultra+.

TABLE 5.3

Fluids Responsible for the SAE Type IV Fluid Holdover Time Table Values

OAT		Type IV Fluid Concentration Neat-Fluid/Water (% by volume)	Approximate Holdover Times Anticipated Under Various Weather Conditions (hours:minutes)					
°C	°F		*FROST	FREEZING FOG	SNOW	***FREEZING DRIZZLE	LIGHT FRZ RAIN	RAIN ON COLD SOAKED WING
above 0°	above 32°	100/0		C-1957(98/99) B	C-1957(98/99) B	H-1957 (96/97) B C-1957(98/99) L	ULTRA+ (98/99) B	SPCA-480 (97/98) U MANY L
		75/25		ABC-S (98/99) B	ULTRA+ (96/97) B	ULTRA+ (96/97) B	ULTRA+ (96/97) B	SPCA-480 (97/98) U MANY L
		50/50		ABC-S (98/99) B	ABC-S (96/97) B ULTRA+ (96/97) B C-2001 (97/98) L ABC-S (98/99) L	ULTRA+ (96/97) B C-2001 (97/98) B ABC-S (98/99) U	ULTRA+ (96/97) B C-1957(98/99) L ABC-S (98/99) B OCT MAX (98/99) L	
0 to -3	32 to 27	100/0		C-1957(98/99) B	C-1957(98/99) B	H-1957 (96/97) B C-1957(98/99) L	ULTRA+ (98/99) B	
		75/25		ABC-S (98/99) B	ULTRA+ (96/97) B	ULTRA+ (96/97) B	ULTRA+ (96/97) B	
		50/50		ABC-S (98/99) B	ABC-S (97/98) B ULTRA+ (96/97) B ABC-S (98/99) B	ULTRA+ (96/97) B C-2001 (97/98) B ABC-S (98/99) U	ULTRA+ (96/97) B	
below -3 to -14	below 27 to 7	100/0		C-1957(98/99) U MANY L	H-1957 (96/97) B	ABC-S (98/99) L C-1957 (98/99) U	ABC-S (98/99) B	
		75/25		ABC-S (98/99) B C-1957(98/99) L	H-1957 (96/97) L ULTRA+ (96/97) L S-404 (97/98) B	OCT MAX (98/99) L ABC-S (98/99) L C-1957(98/99) U	ABC-S (98/99) L MANY U	
below -14 to -25	below 7 to -13	100/0		C-1957(98/99) L OCT MAX (98/99) B ABC-S (98/99) B	H-1957 (96/97) B			
below -25	below -13	100/0	SAE TYPE IV fluid may be used below -25°C (-13°F) provided the freezing point of the fluid is at least 7°C (13°F) below the OAT and the aerodynamic acceptance criteria are met. Consider use of SAE Type I when SAE Type IV fluid cannot be used.				**LEGEND** **L = DRIVES LOWER LIMIT** **U = DRIVES UPPER LIMIT** **B = DRIVES BOTH**	

5.3 Type II Fluid Holdover Time Tests

Type II fluid is a thickened fluid used to provide anti-icing protection to aircraft surfaces following deicing. The Type II fluid holdover time table, substantiated by previous testing and accepted for use in 1998-99, is shown in Table 1.3 (Section 1). The new Type II holdover time table, which was accepted for use in 1999-2000 by the SAE G-12 Holdover Time Subcommittee in Toronto, and the fluid-specific holdover time table for Kilfrost ABC-II Plus are shown in Tables 5.7 and 5.8 (Section 5.6).

The SAE holdover time table for Type II fluid was developed based on the results of holdover time tests conducted during previous years. In addition to these tests, one Type II fluid, Kilfrost ABC-II Plus (formerly Kilfrost ABC-3+), was tested by APS during the past test season. At the SAE Holdover Time Subcommittee meetings in Toronto, the fluid manufacturer requested a fluid-specific table for this fluid. The request was accepted. The changes made to the previous Type II holdover time table, based on the results of this new fluid, will be discussed in this section.

It has been stipulated through discussion by the SAE G-12 Holdover Time Subcommittee that the holdover times for any cell in the Type II table may not exceed the holdover times for that same cell in the Type IV fluid table. This is primarily due to the fact that all Type IV fluids qualify as Type II fluids and are expected to exhibit superior performance over that of Type II fluids. Type II fluids, on the other hand, do not qualify as Type IV fluids. The imposing of holdover time reductions based on this consideration has been referred to as *Type IV fluid holdover time constraint.*

Five changes were made to the Type II holdover time table based on the Type IV fluid holdover time constraint. Although reducing Type II holdover times based on the results of Type IV tests has become routine, there are those within the SAE G-12 that disagree with this practice.

5.3.1 Natural Snow

The natural snow holdover time data for Kilfrost ABC-II Plus originated from 1998-99 tests conducted at the Dorval Airport test facility.

5.3.1.1 Changes to the Type II Fluid Holdover Times for Snow

The tables are formatted to show columns containing the 1998-99 SAE, 1999-2000 SAE and the Kilfrost ABC-II Plus fluid-specific holdover times for each cell of the holdover time tables.

i. Neat fluid, above 0°C, snow (Figure 5.28)

1998-99 SAE
0:20-1:00

1999-00 SAE	K-ABC-II Plus
0:20-1:00	0:35-1:20

The SAE holdover time in this cell remains the same. The fluid-specific values for the Kilfrost ABC-II Plus are above those of the generic table.

ii. 75/25 fluid, above 0°C, snow (Figure 5.29)

1998-99 SAE
0:15-0:40

1999-00 SAE	K-ABC-II Plus
0:15-0:40	0:35-1:10

The SAE holdover time numbers in this cell remain unchanged from last year. The fluid-specific values for the Kilfrost ABC-II Plus are well above those of the generic table.

iii. 50/50 fluid, above 0°C, snow (Figure 5.30)

1998-99 SAE
0:05-0:15

1999-00 SAE	K-ABC-II Plus
0:05-0:15	0:20-0:40

The SAE holdover times in this cell are unchanged from last year. The Kilfrost fluid, once again, has holdover times well above those of the generic values.

iv. Neat fluid, 0°C to -3°C, snow (Figure 5.28)

1998-99 SAE
0:20-0:45

1999-00 SAE	K-ABC-II Plus
0:20-0:45	0:25-0:55

The SAE holdover times in this cell are unchanged from last year. The Kilfrost fluid has holdover times above those of the generic values.

FIGURE 5.28

EFFECT OF TEMPERATURE AND RATE OF PRECIPITATION ON ENDURANCE TIME

KILFROST ABC-II PLUS NEAT

NATURAL SNOW CONDITIONS

1998-99

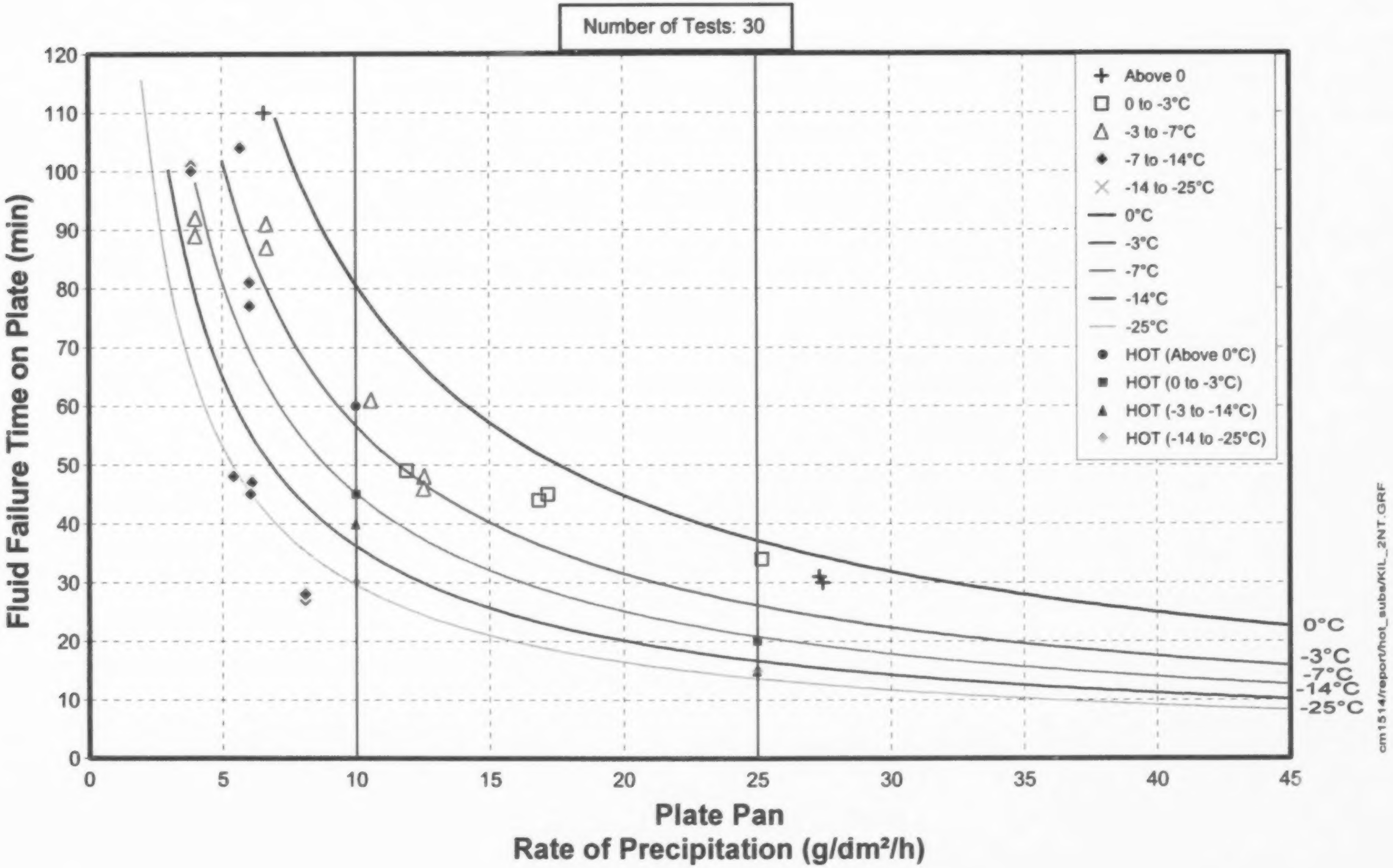


FIGURE 5.29

EFFECT OF TEMPERATURE AND RATE OF PRECIPITATION ON ENDURANCE TIME

KILFROST ABC-II PLUS 75/25

NATURAL SNOW CONDITIONS

1998-99

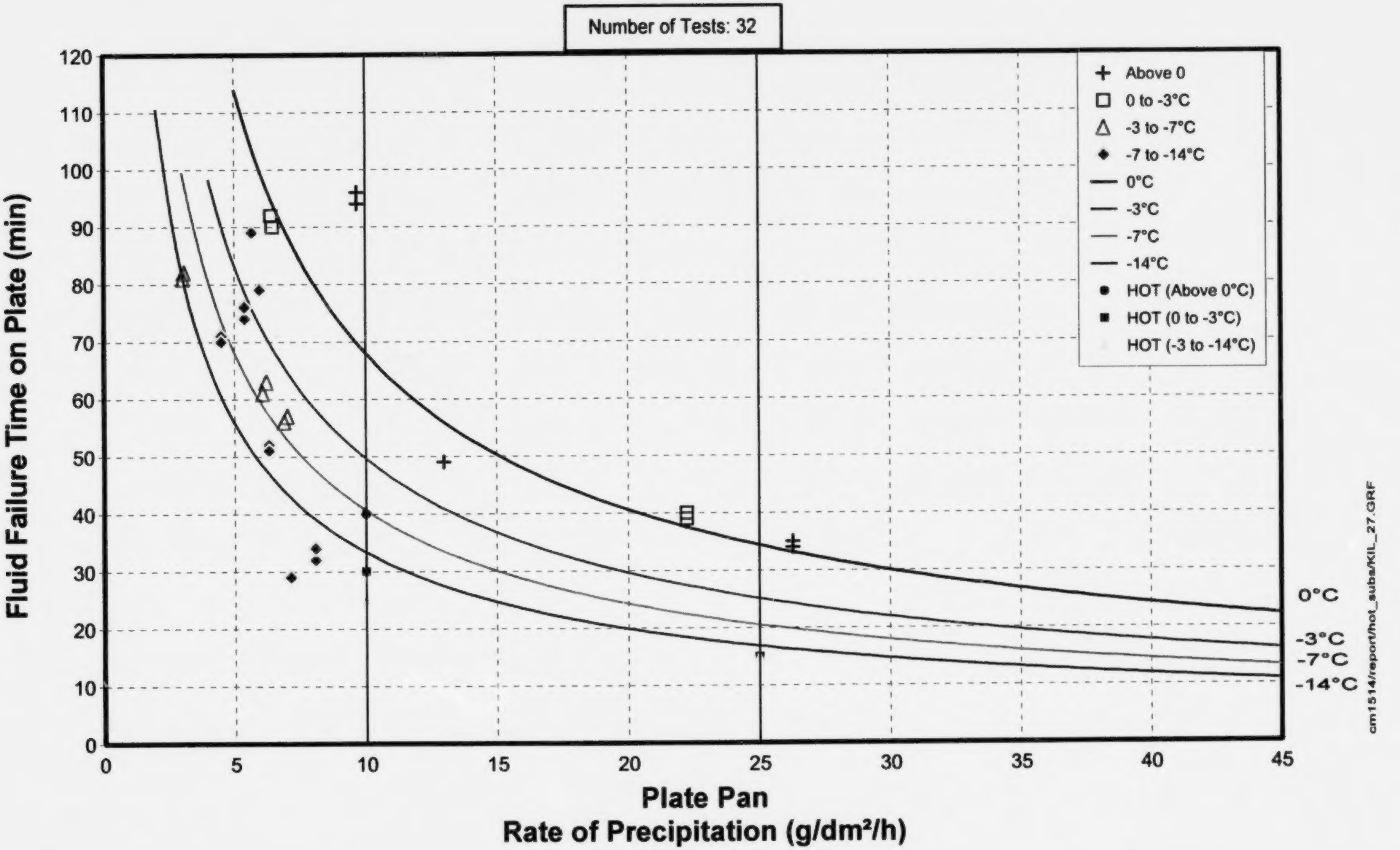


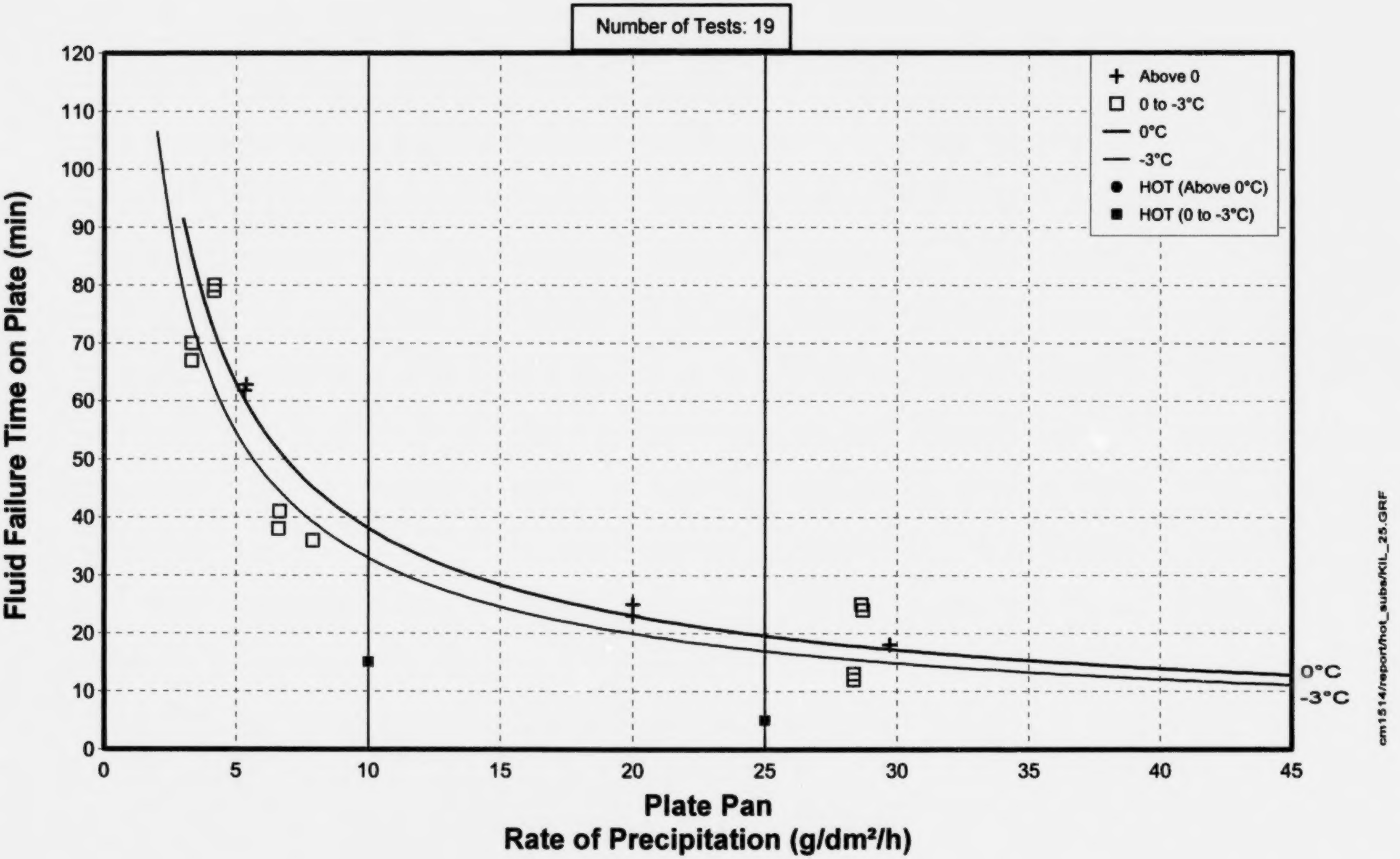
FIGURE 5.30

EFFECT OF TEMPERATURE AND RATE OF PRECIPITATION ON ENDURANCE TIME

KILFROST ABC-II PLUS 50/50

NATURAL SNOW CONDITIONS

1998-99



v. 75/25 fluid, 0°C to -3°C, snow (Figure 5.29)

1998-99 SAE
0:15-0:30

1999-00 SAE	K-ABC-II Plus
0:15-0:30	0:25-0:50

The SAE holdover times in this cell are unchanged from last year. The Kilfrost fluid has holdover times well above those of the generic values.

vi. 50/50 fluid, 0°C to -3°C, snow (Figure 5.30)

1998-99 SAE
0:05-0:15

1999-00 SAE	K-ABC-II Plus
0:05-0:15	0:15-0:35

The SAE holdover times in this cell are unchanged from last year. The Kilfrost fluid has holdover times well above those of the generic values.

vii. Neat fluid, -3°C to -14°C, snow (Figure 5.28)

1998-99 SAE
0:15-0:40

1999-00 SAE	K-ABC-II Plus
0:15-0:35	0:15-0:35

The upper SAE holdover time in this cell was reduced by 5 minutes based on the result of the Kilfrost fluid.

viii. 75/25 fluid, -3°C to -14°C, snow (Figure 5.29)

1998-99 SAE
0:15-0:30

1999-00 SAE	K-ABC-II Plus
0:15-0:25	0:15-0:35

The upper SAE Type II holdover time in this cell was reduced by 5 minutes based on Type IV fluid tests in this cell.

ix. Neat fluid, -14°C to -25°C, snow (Figure 5.28)

1998-99 SAE
0:15-0:30

1999-00 SAE	K-ABC-II Plus
0:15-0:30	0:15-0:30

The holdover times in this cell remain unchanged from last year.

5.3.1.2 Overall Perspective on Snow Results

Two changes were made to the current SAE generic table, one based on the results of testing conducted with Kilfrost ABC-II Plus, the other due to Type IV fluid holdover time constraint. In general, the performance of the new Kilfrost fluid is superior to the generic Type II fluid holdover times at warm temperatures (above -3°C).

5.3.2 Freezing Drizzle

The following is a cell-by-cell summary of the holdover time performance of the Type II fluid (ABC-II Plus) tested under conditions of simulated freezing drizzle. The results are arranged in the sequence of temperature ranges (from top to bottom) that appear in the corresponding columns of the holdover time tables. Because it was not possible to simulate freezing drizzle above 0°C, the holdover time results for this category of precipitation above 0°C are identical to those in the range of 0°C to -3°C.

Each table shows columns containing the 1998-99 SAE, 1999-2000 SAE, and the Kilfrost ABC-II Plus fluid-specific holdover times.

5.3.2.1 Changes to Type II Fluid Holdover Times for Freezing Drizzle

i. Neat fluid, above 0°C and 0°C to -3°C, freezing drizzle (Figure 5.31)

1998-99 SAE
0:30-1:00

1999-00 SAE	K-ABC-II Plus
0:30-1:00	0:35-1:10

The holdover times in these cells remain unchanged from last year. The Kilfrost fluid slightly outperforms the generic numbers.

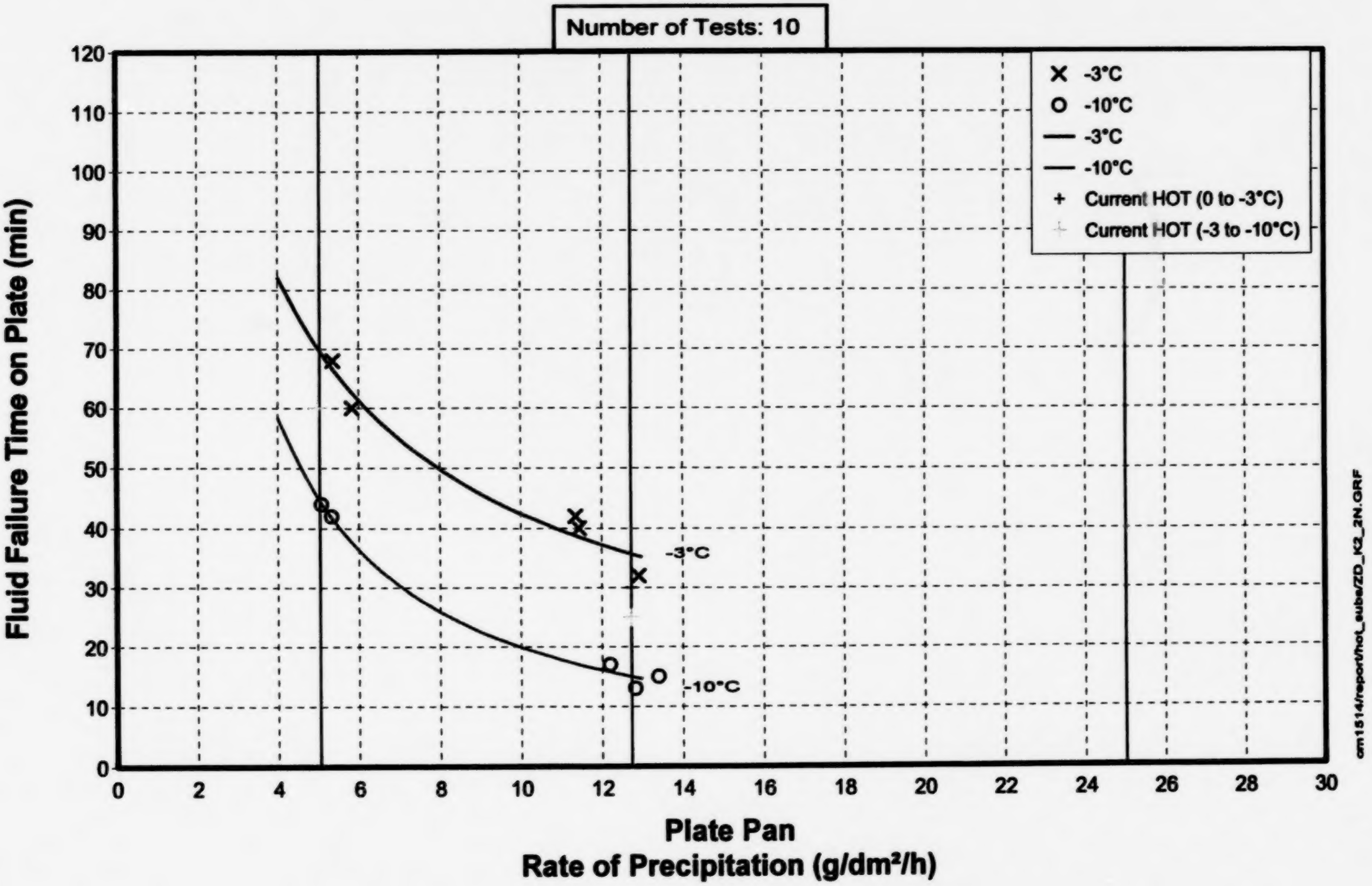
FIGURE 5.31

EFFECT OF TEMPERATURE AND RATE OF PRECIPITATION ON ENDURANCE TIME

KILFROST ABC-II PLUS NEAT

SIMULATED FREEZING DRIZZLE

1998-99



ii. 75/25 fluid, above 0°C and 0°C to -3°C, freezing drizzle (Figure 5.32)

1998-99 SAE
0:20-0:45

1999-00 SAE	K-ABC-II Plus
0:20-0:45	0:30-1:00

The holdover times in these cells remain unchanged from last year. The Kilfrost fluid outperforms the generic numbers in this cell.

iii. 50/50 fluid, above 0°C and 0°C to -3°C, freezing drizzle (Figure 5.33)

1998-99 SAE
0:10-0:20

1999-00 SAE	K-ABC-II Plus
0:05-0:20	0:05-0:25

The lower SAE holdover times for these two cells were reduced by 5 minutes based on the results of the Kilfrost fluid.

iv. Neat fluid, -3° C to -10°C, freezing drizzle (Figure 5.31)

1998-99 SAE
0:30-1:00

1999-00 SAE	K-ABC-II Plus
0:15-0:45	0:15-0:45

The SAE lower and upper holdover time limits for neat fluid in this temperature range for this precipitation type were reduced from the previous SAE numbers based on results of tests conducted with Kilfrost ABC-II Plus.

It should also be noted that the Type IV holdover times in this cell are both below the 1998-99 generic Type II holdover times.

v. 75/25 fluid, -3°C to -10°C, freezing drizzle (Figure 5.32)

1998-99 SAE
0:20-0:45

1999-00 SAE	K-ABC-II Plus
0:15-0:30	0:15-0:30

The SAE upper and lower holdover times for 75/25 fluid in freezing drizzle were reduced based on the results of Kilfrost testing.

FIGURE 5.32

EFFECT OF TEMPERATURE AND RATE OF PRECIPITATION ON ENDURANCE TIME

KILFROST ABC-II PLUS 75/25

SIMULATED FREEZING DRIZZLE
1998-99

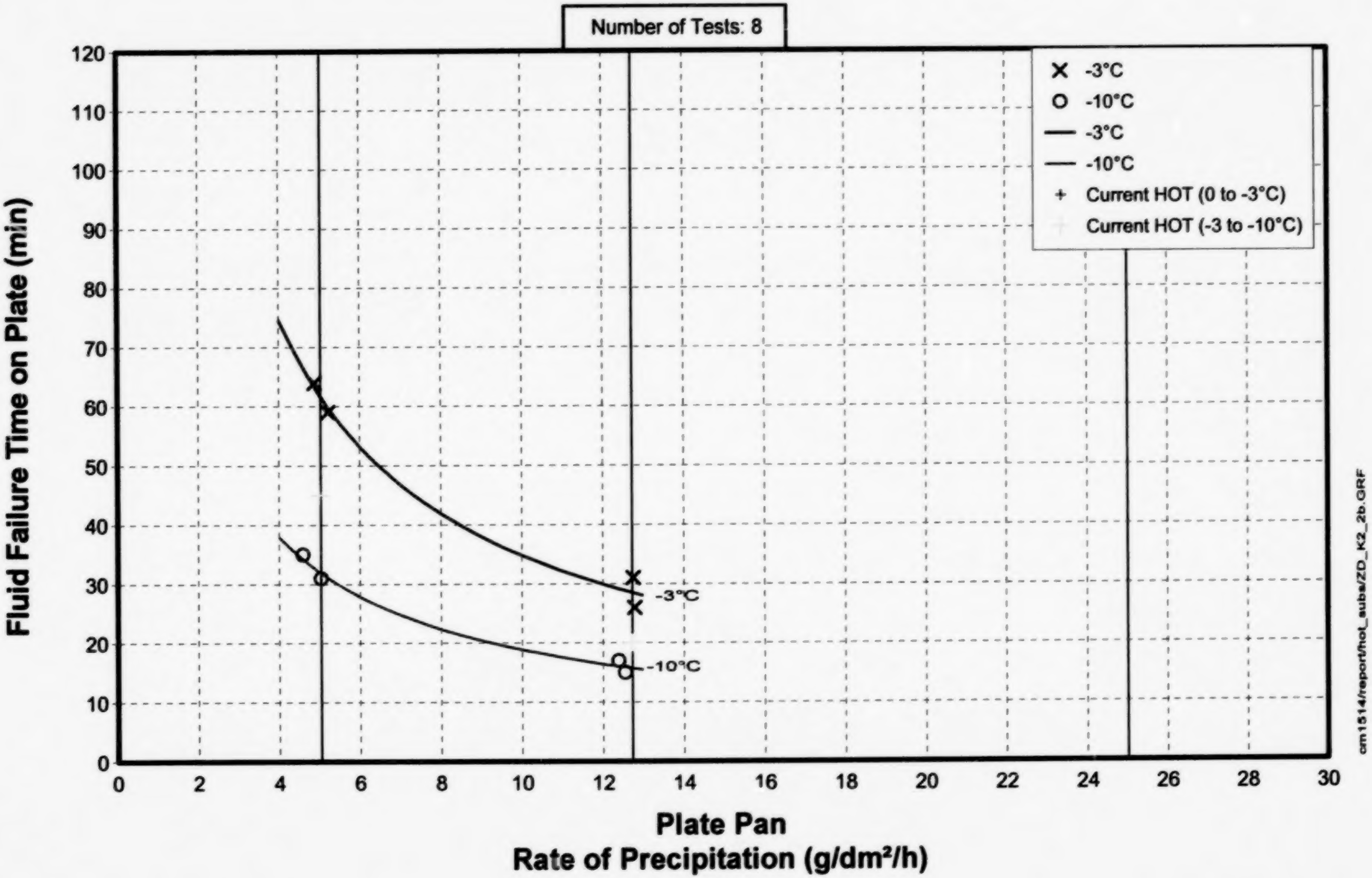


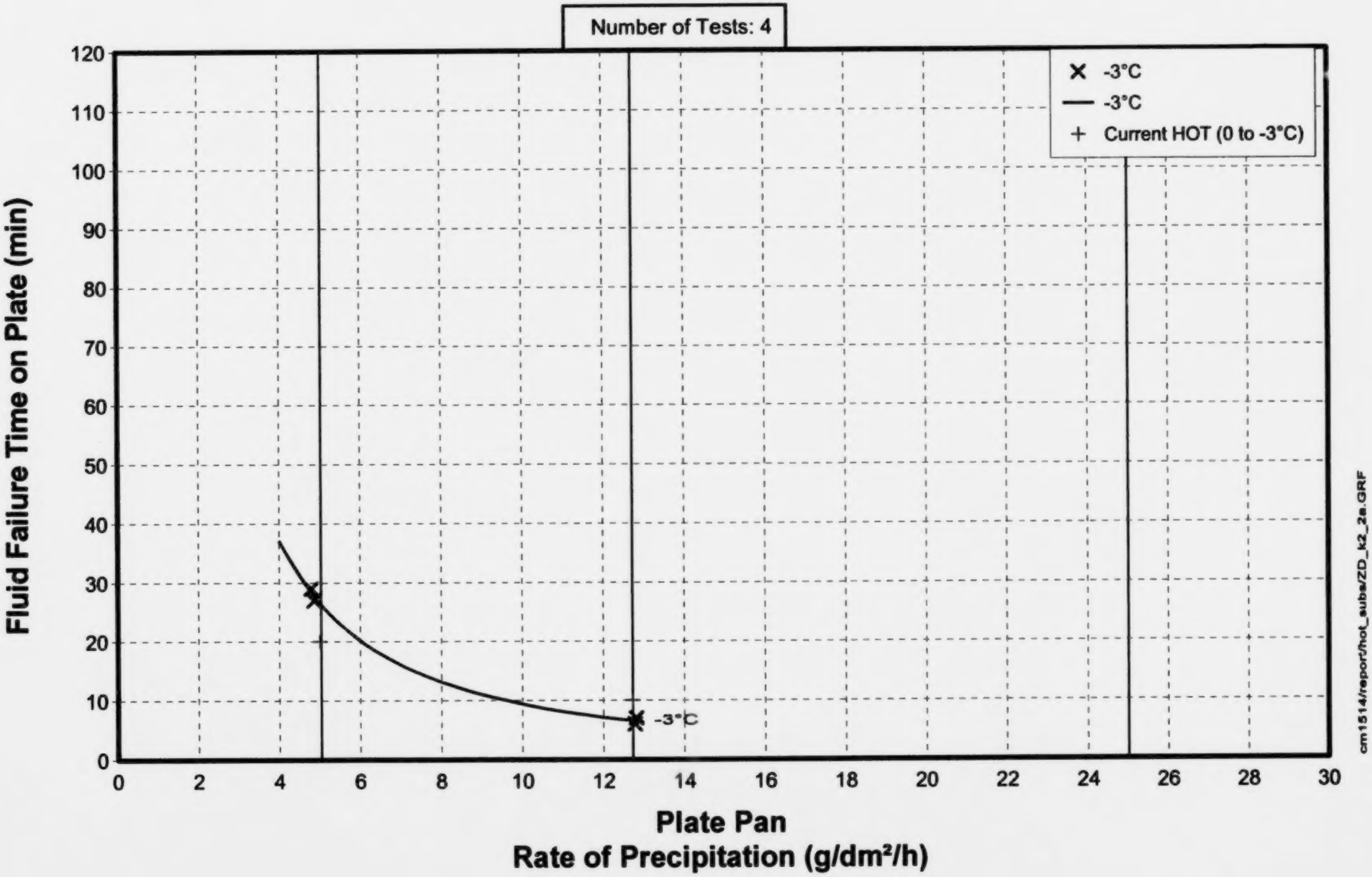
FIGURE 5.33

EFFECT OF TEMPERATURE AND RATE OF PRECIPITATION ON ENDURANCE TIME

KILFROST ABC-II PLUS 50/50

SIMULATED FREEZING DRIZZLE

1998-99



5.3.2.2 Overall Perspective on Freezing Drizzle Results

Six changes were made to the SAE Type II table from last year. In the colder cells of the freezing drizzle column (-3°C to -10°C), the reductions were significant.

5.3.3 Light Freezing Rain

The following is a cell-by-cell summary of the holdover time performance of Type II fluid tested under conditions of simulated light freezing rain. The results are arranged in the sequence of temperature ranges (from top to bottom) that appear in the corresponding columns of the holdover time tables. Because it was not possible to simulate freezing precipitation above 0°C, the holdover time results for this category of precipitation above 0°C are identical to those in the range of 0°C to -3°C.

Each table shows the 1998-99 SAE, 1999-2000 SAE, and the Kilfrost ABC-II Plus fluid-specific holdover times.

5.3.3.1 Changes to Type II Fluid Holdover Times for Light Freezing Rain

i. Neat fluid, above 0°C and 0 to -3°C, light freezing rain (Figure 5.34)

1998-99 SAE	
0:15-0:30	
1999-00 SAE	**K-ABC-II Plus**
0:15-0:30	0:30-0:40

The holdover times remain unchanged in these cells of the Type II table for light freezing rain. The holdover times of the Kilfrost fluid far surpass the generic numbers.

ii. 75/25 fluid, above 0°C and 0 to -3°C, light freezing rain (Figure 5.35)

1998-99 SAE	
0:10-0:25	
1999-00 SAE	**K-ABC-II Plus**
0:10-0:25	0:20-0:40

The SAE holdover times remain unchanged in these two cells. The holdover times of the Kilfrost fluid are greater than those of the generic Type II holdover time values.

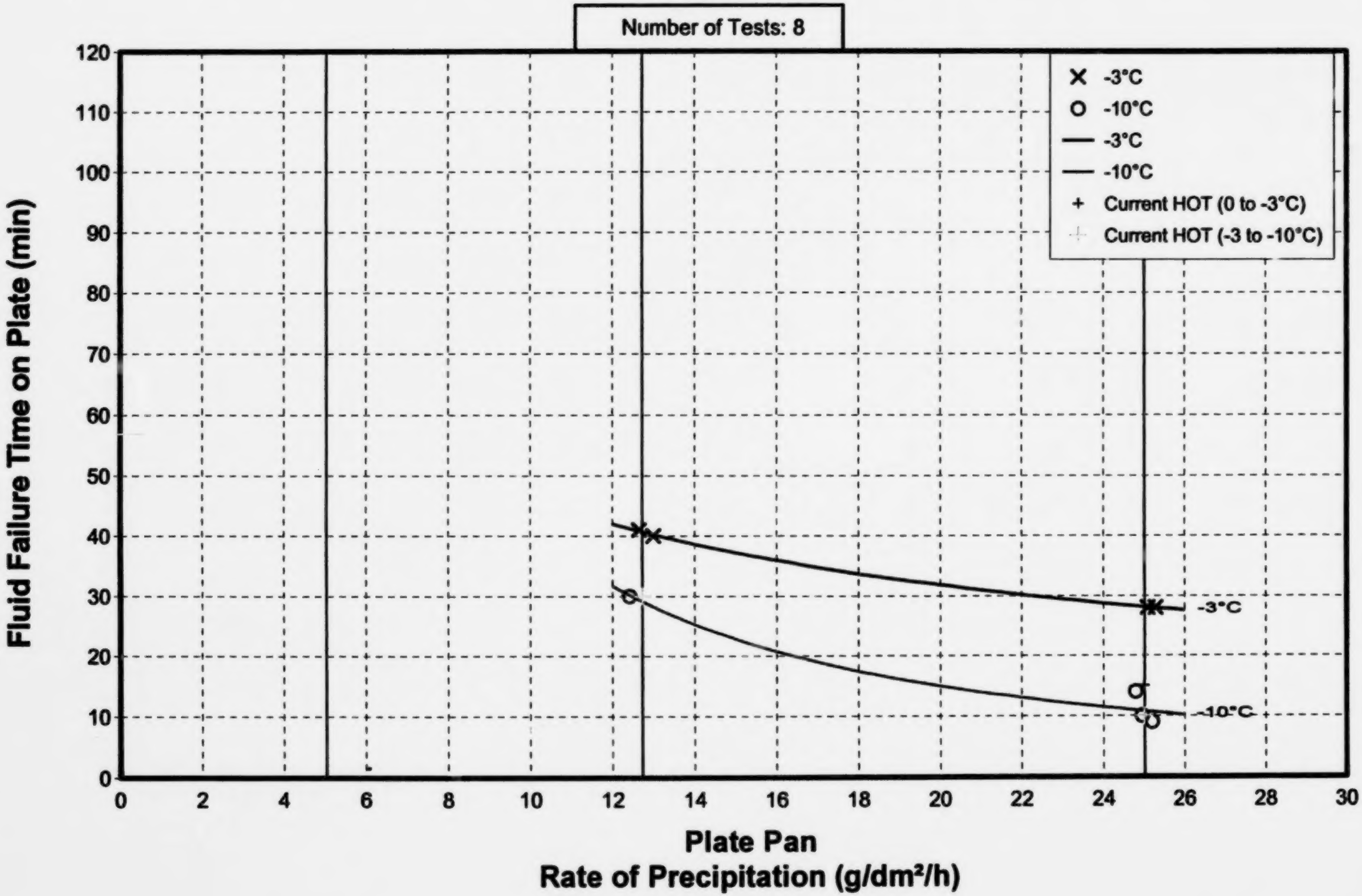
FIGURE 5.34

EFFECT OF TEMPERATURE AND RATE OF PRECIPITATION ON ENDURANCE TIME

KILFROST ABC-II PLUS NEAT

SIMULATED LIGHT FREEZING RAIN

1998-99



cm1514/report/hot_subs/ZR_K2_2N.GRF

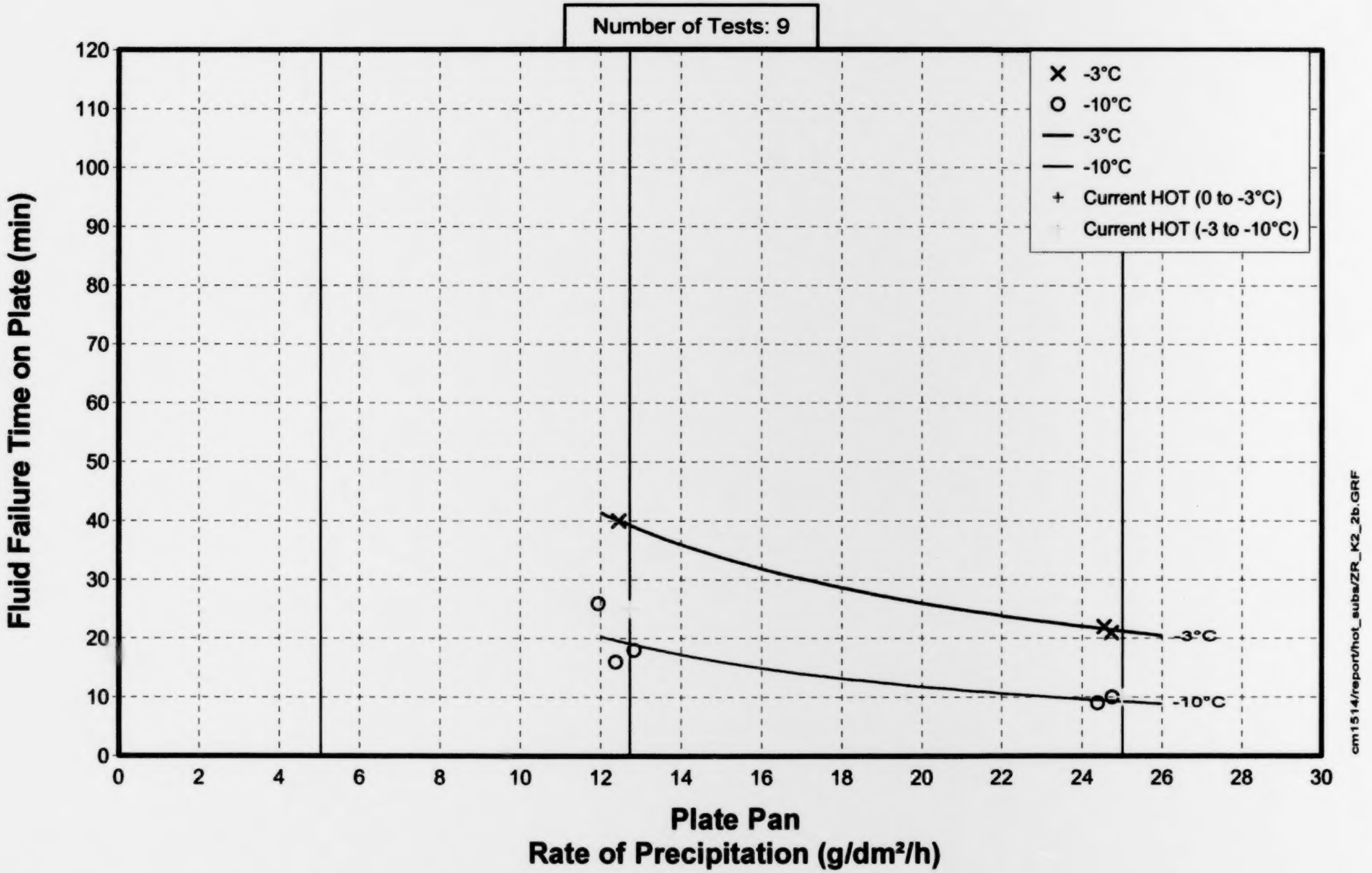
FIGURE 5.35

EFFECT OF TEMPERATURE AND RATE OF PRECIPITATION ON ENDURANCE TIME

KILFROST ABC-II PLUS 75/25

SIMULATED LIGHT FREEZING RAIN

1998-99



iii. 50/50 fluid, above 0°C and 0 to -3°C, light freezing rain (Figure 5.36)

1998-99 SAE
0:05-0:10

1999-00 SAE	K-ABC-II Plus
0:05-0:10	0:05-0:15

The SAE values were not changed in these two cells.

iv. Neat fluid, -3° C to -10°C, light freezing rain (Figure 5.34)

1998-99 SAE
0:10-0:30

1999-00 SAE	K-ABC-II Plus
0:10-0:30	0:10-0:30

The SAE holdover times for neat fluid in this temperature range for this precipitation type remain unchanged from last year. The Kilfrost fluid displayed similar holdover time performance to that indicated in the generic Type II holdover time table.

v. 75/25 fluid, -3°C to -10°C, light freezing rain (Figure 5.35)

1998-99 SAE
0:10-0:25

1999-00 SAE	K-ABC-II Plus
0:10-0:20	0:10-0:20

The upper SAE holdover time in this cell was reduced by 5 minutes, based on the result of the Kilfrost fluid.

5.3.3.2 Overall Perspective on Light Freezing Rain Results

Only one change was made to the SAE Type II table. In this case, the upper holdover time limit in the -3°C to -10°C cell for 75/25 fluid was reduced by 5 minutes.

5.3.4 Freezing Fog

The freezing fog category is divided into nine cells. The data were collected under precipitation rates of 2 and 5 g/dm^2/h. Tests conducted prior to 1998-99 did not use the lower precipitation rate limit of

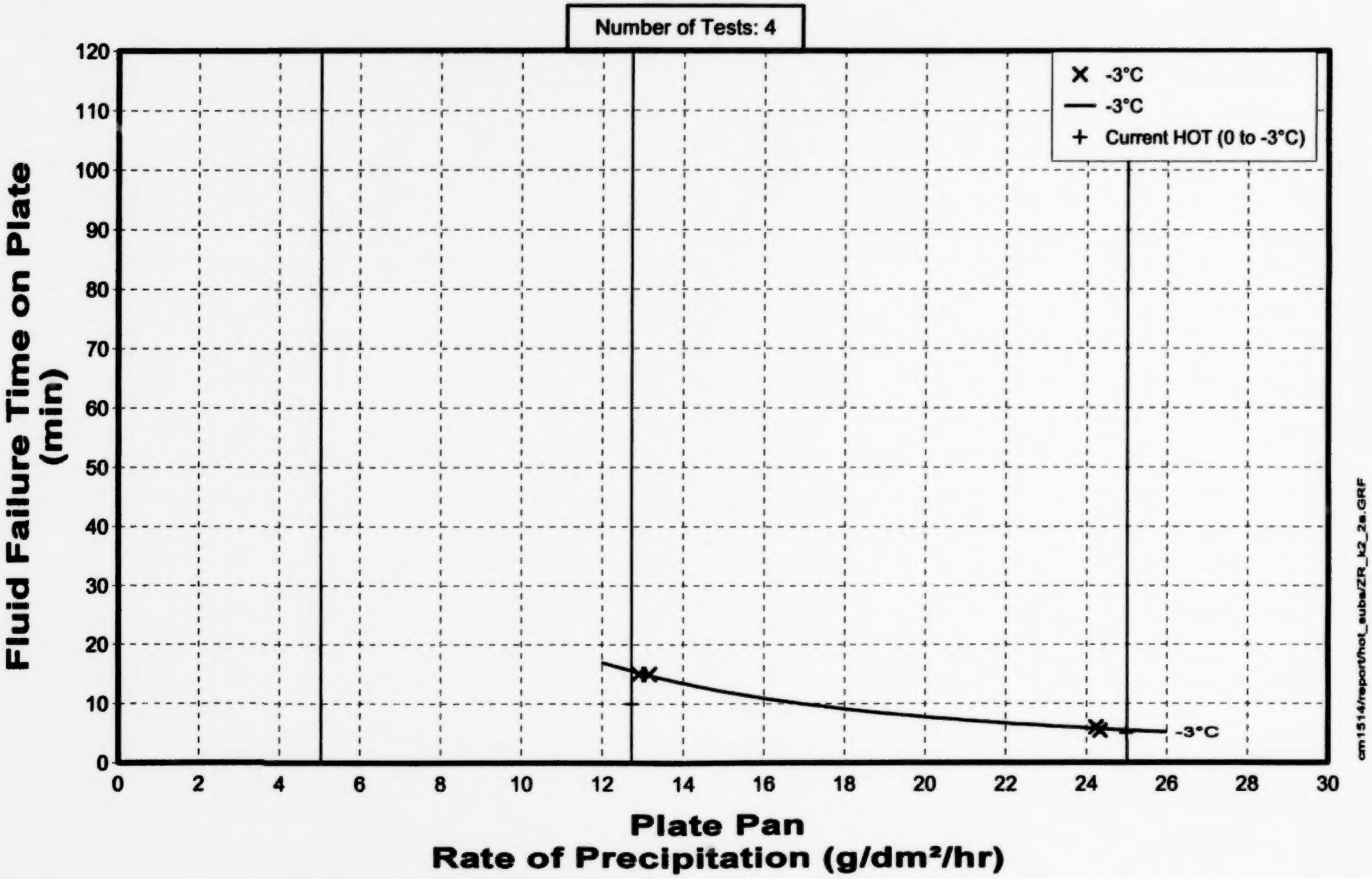
FIGURE 5.36

EFFECT OF TEMPERATURE AND RATE OF PRECIPITATION ON ENDURANCE TIME

KILFROST ABC-II PLUS 50/50

SIMULATED LIGHT FREEZING RAIN

1998-99



2 g/dm²/h, and as such, several reductions were made to the Type IV SAE table in freezing fog.

Failure times were measured at three different temperatures, -3°C, -14°C, and -25°C.

The tables have been formatted to show the 1998-99 SAE, 1999-2000 SAE and the Kilfrost ABC-II Plus fluid-specific holdover times for each cell of the holdover time tables.

5.3.4.1 Changes to Type II Fluid Holdover Times for Freezing Fog

i. Neat fluid, above 0°C, freezing fog (Figure 5.37)

1998-99 SAE
1:15-3:00

1999-00 SAE	K-ABC-II Plus
1:05-2:15	1:10-2:25

The current holdover time limits were reduced substantially, based on Type IV fluid holdover time constraint.

ii. 75/25 fluid, above 0°C, freezing fog (Figure 5.38)

1998-99 SAE
0:50-2:00

1999-00 SAE	K-ABC-II Plus
0:50-1:45	1:10-2:25

The upper SAE holdover time for fluids in these cells is driven by the result of Type IV tests conducted during the 1998-99 test season. The Kilfrost fluid performance is superior to that of the SAE Type II holdover times.

iii. 50/50 fluid, above 0°C, freezing fog (Figure 5.39)

1998-99 SAE
0:20-0:45

1999-00 SAE	K-ABC-II Plus
0:15-0:35	0:15-0:45

Both the upper and lower holdover time limits were reduced. The lower limit was reduced to match the result of the Kilfrost fluid, while the upper limit was reduced to match the corresponding number in the Type IV table.

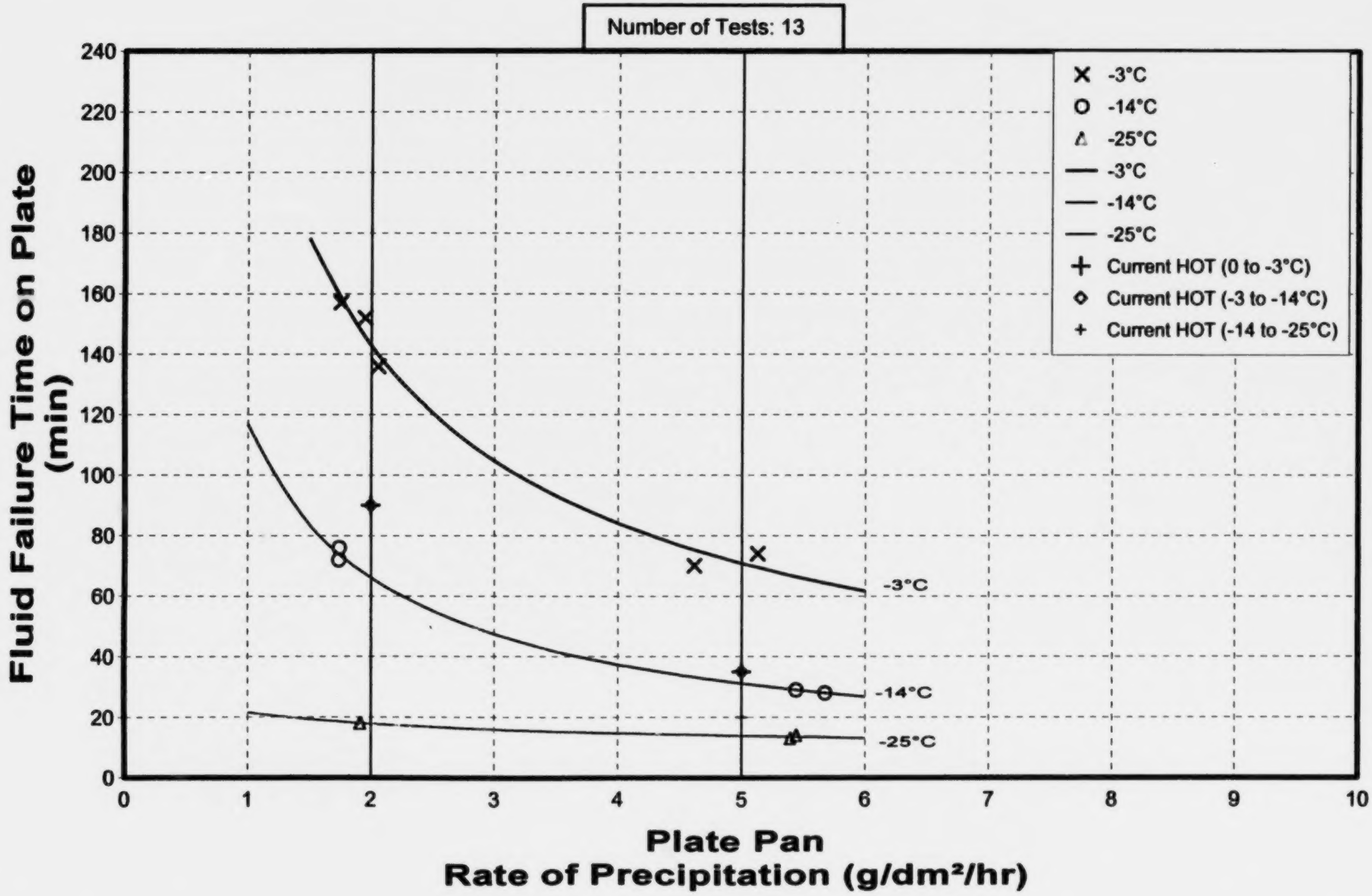
FIGURE 5.37

EFFECT OF TEMPERATURE AND RATE OF PRECIPITATION ON ENDURANCE TIME

KILFROST ABC-II PLUS NEAT

SIMULATED FREEZING FOG

1998-99



cm1514/report/hot_subs/ZF_K2_2N.GRF

FIGURE 5.38

EFFECT OF TEMPERATURE AND RATE OF PRECIPITATION ON ENDURANCE TIME

KILFROST ABC-II PLUS 75/25

SIMULATED FREEZING FOG

1998-99

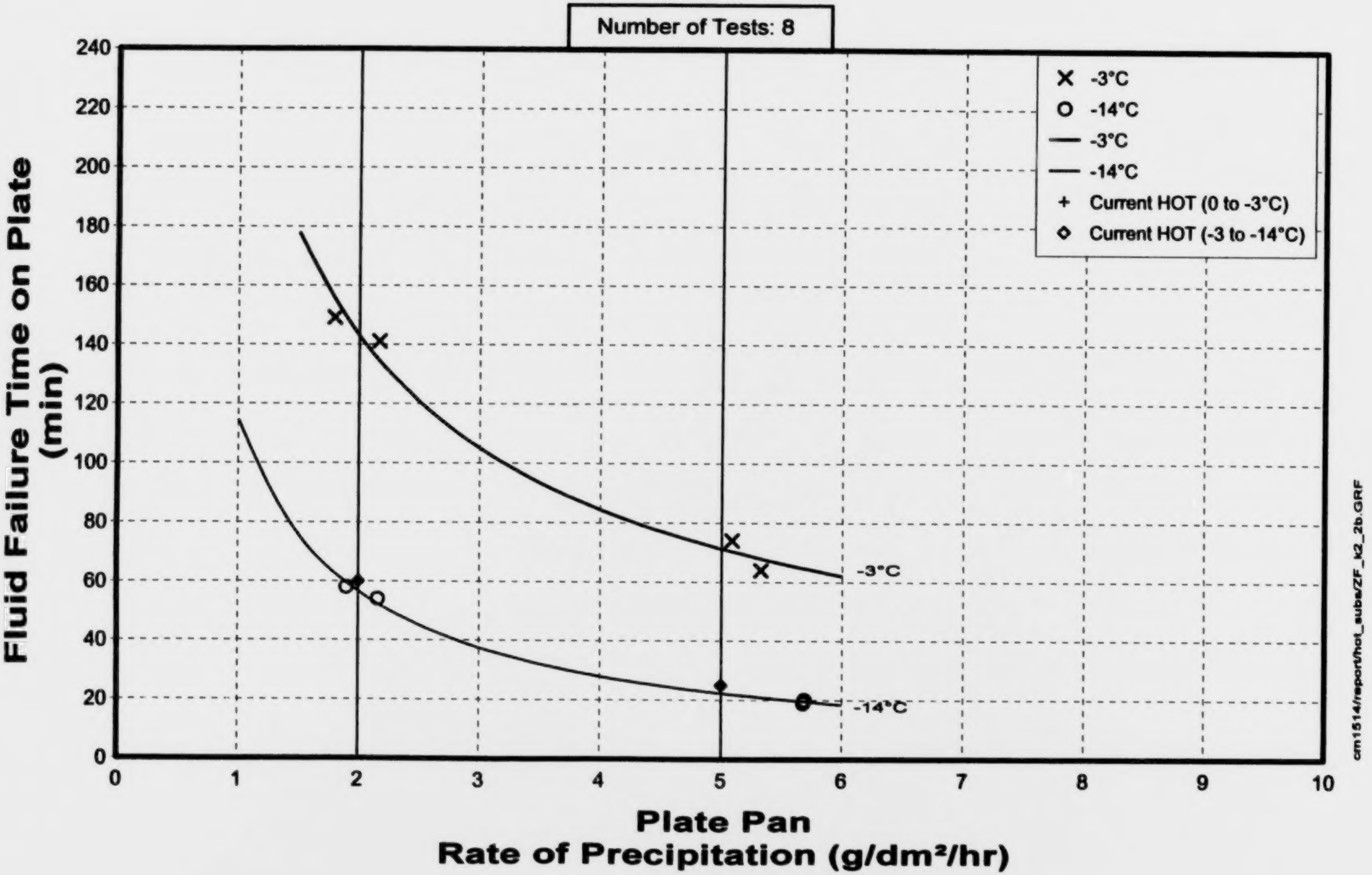


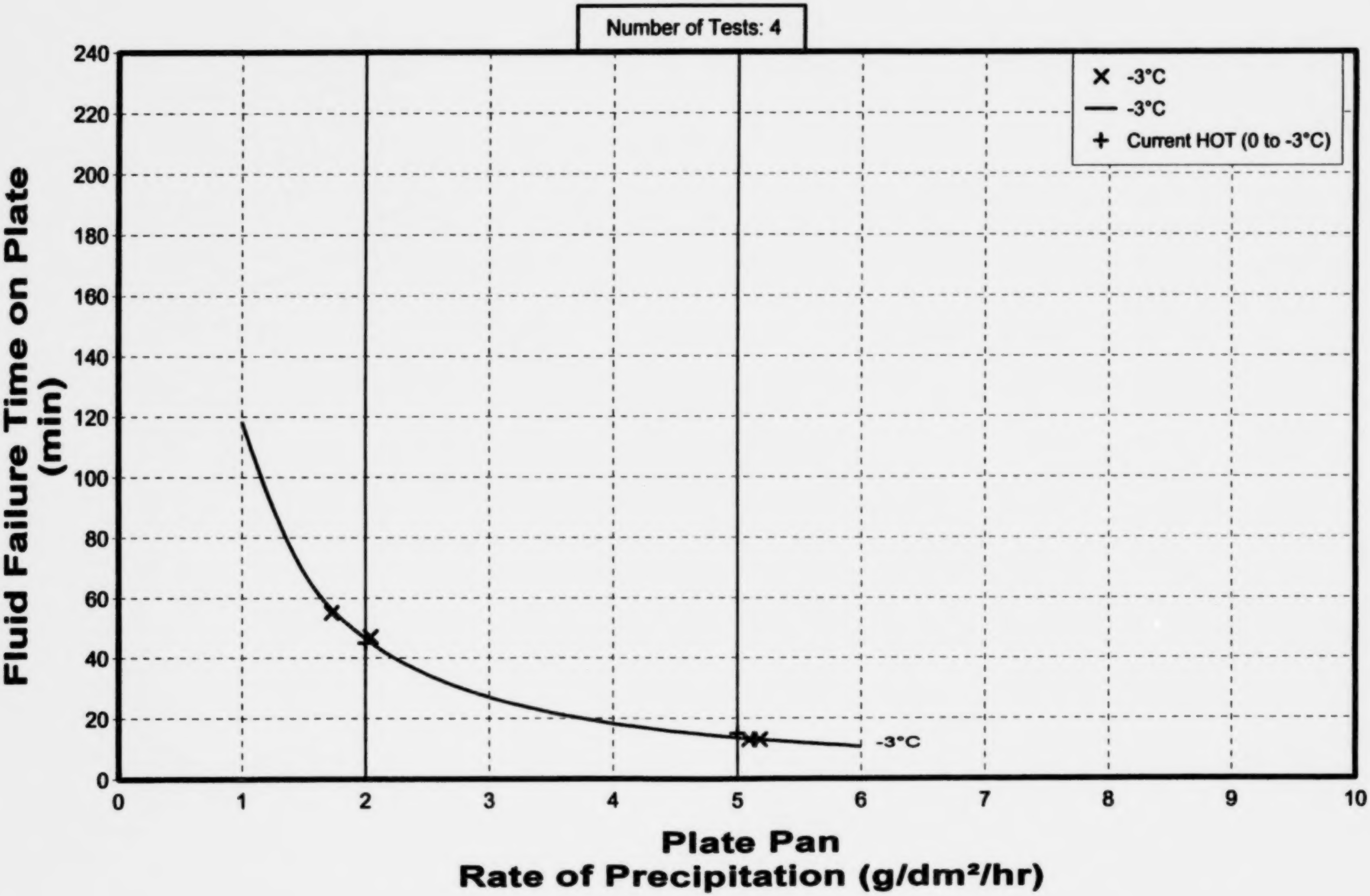
FIGURE 5.39

EFFECT OF TEMPERATURE AND RATE OF PRECIPITATION ON ENDURANCE TIME

KILFROST ABC-II PLUS 50/50

SIMULATED FREEZING FOG

1998-99



cm1514/report/hot_subs/ZF_K2_2A.GRF

iv. Neat fluid, 0°C to -3°C, freezing fog (Figure 5.37)

1998-99 SAE
0:35-1:30

1999-00 SAE	K-ABC-II Plus
0:35-1:30	1:10-2:25

The current holdover time limits were not reduced based on recent testing. The Kilfrost fluid performs significantly better than the SAE values.

v. 75/25 fluid, 0°C to -3°C, freezing fog (Figure 5.38)

1998-99 SAE
0:25-1:00

1999-00 SAE	K-ABC-II Plus
0:25-1:00	1:10-2:25

The current holdover time limits were not reduced based on recent testing. The Kilfrost fluid performs significantly better than the SAE values.

vi. 50/50 fluid, 0°C to -3°C, freezing fog (Figure 5.39)

1998-99 SAE
0:15-0:45

1999-00 SAE	K-ABC-II Plus
0:15-0:35	0:15-0:45

The upper holdover time limit was reduced based on a reduction in the corresponding Type IV cell.

vii. Neat fluid, -3 to -14°C, freezing fog (Figure 5.37)

1998-99 SAE
0:35-1:30

1999-00 SAE	K-ABC-II Plus
0:30-1:05	0:30-1:05

The upper and lower SAE holdover times for fluids in this cell were reduced based on the results of tests conducted with the Kilfrost fluid.

viii. 75/25 fluid, -3 to -14°C, freezing fog (Figure 5.38)

1998-99 SAE
0:25-1:00

1999-00 SAE	K-ABC-II Plus
0:20-0:55	0:20-0:55

The upper and lower SAE holdover times in this cell were reduced by 5 minutes to match the results of tests conducted with the Kilfrost fluid.

ix. Neat fluid, -14° to -25°C, freezing fog (Figure 5.37)

1998-99 SAE
0:20-1:30

1999-00 SAE	K-ABC-II Plus
0:15-0:20	0:15-0:20

The lower holdover time was reduced by 5 minutes, while the upper number was reduced substantially, based on the results of the Kilfrost fluid.

5.3.4.2 Overall Perspective on Freezing Fog Results

Twelve changes were made to the freezing fog column in the SAE Type II table. Eight changes were due to the performance of the Kilfrost fluid. Four additional changes were due to reductions in the SAE Type IV fluid holdover time table.

5.3.5 Rain on a Cold-Soaked Wing

The data used to evaluate the holdover times for this category of precipitation covered precipitation rates ranging from 5 $g/dm^2/h$ to 76 $g/dm^2/h$. This encompasses heavy drizzle (5 to 12.7 $g/dm^2/h$), light rain (12.7 to 25 $g/dm^2/h$), and moderate rain (25 to 76 $g/dm^2/h$). The cold-soak test boxes were 7.5 cm deep. Dimensional details are described in Section 2. The box temperature prior to the start of testing was -10°C.

The data are plotted for two Type II fluid concentrations: neat fluid and 75/25 fluid.

5.3.5.1 Changes to Type II Fluid Holdover Times for Rain on a Cold-Soaked Wing

i. Neat fluid, above 0°C, rain on a cold-soaked wing (Figure 5.40)

1998-99 SAE 0:10-0:40	
1999-00 SAE 0:05-0:40	K-ABC-II Plus 0:05-1:00

The lower limit of the holdover time range was reduced by 5 minutes based on the results of the Kilfrost fluid.

ii. 75/25 fluid, above 0°C, rain on a cold-soaked wing (Figure 5.41)

1998-99 SAE 0:05-0:25	
1999-00 SAE 0:05-0:25	K-ABC-II Plus 0:05-0:50

The holdover times in this cell remain unchanged from last year.

5.3.5.2 Overall Perspective on Rain on a Cold-Soaked Wing Results

Only one change was made to the rain on a cold-soaked wing holdover times.

FIGURE 5.40

EFFECT OF RATE OF PRECIPITATION ON ENDURANCE TIME

KILFROST ABC-II PLUS NEAT

RAIN ON COLD-SOAKED SURFACE

1998-99

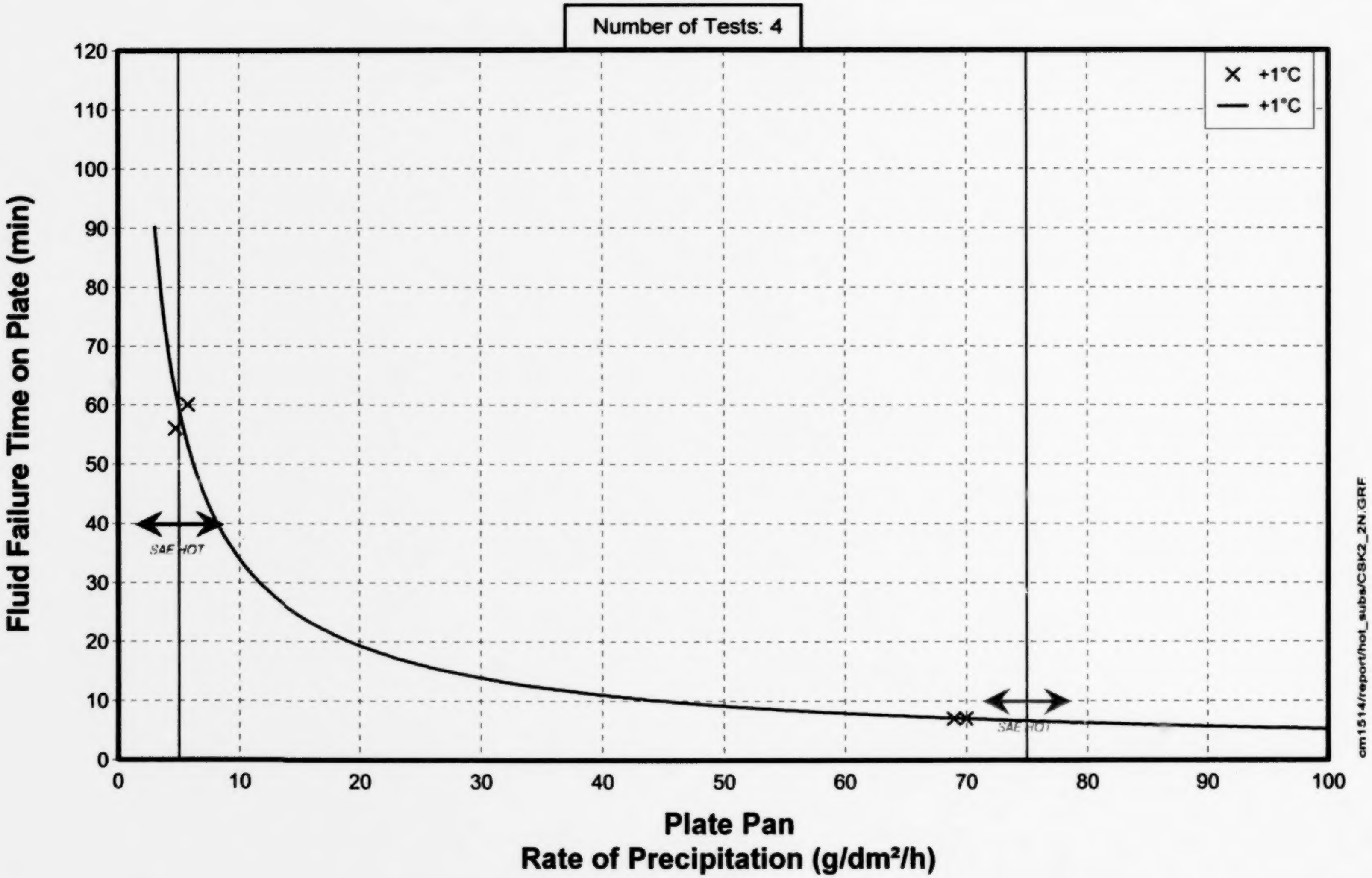
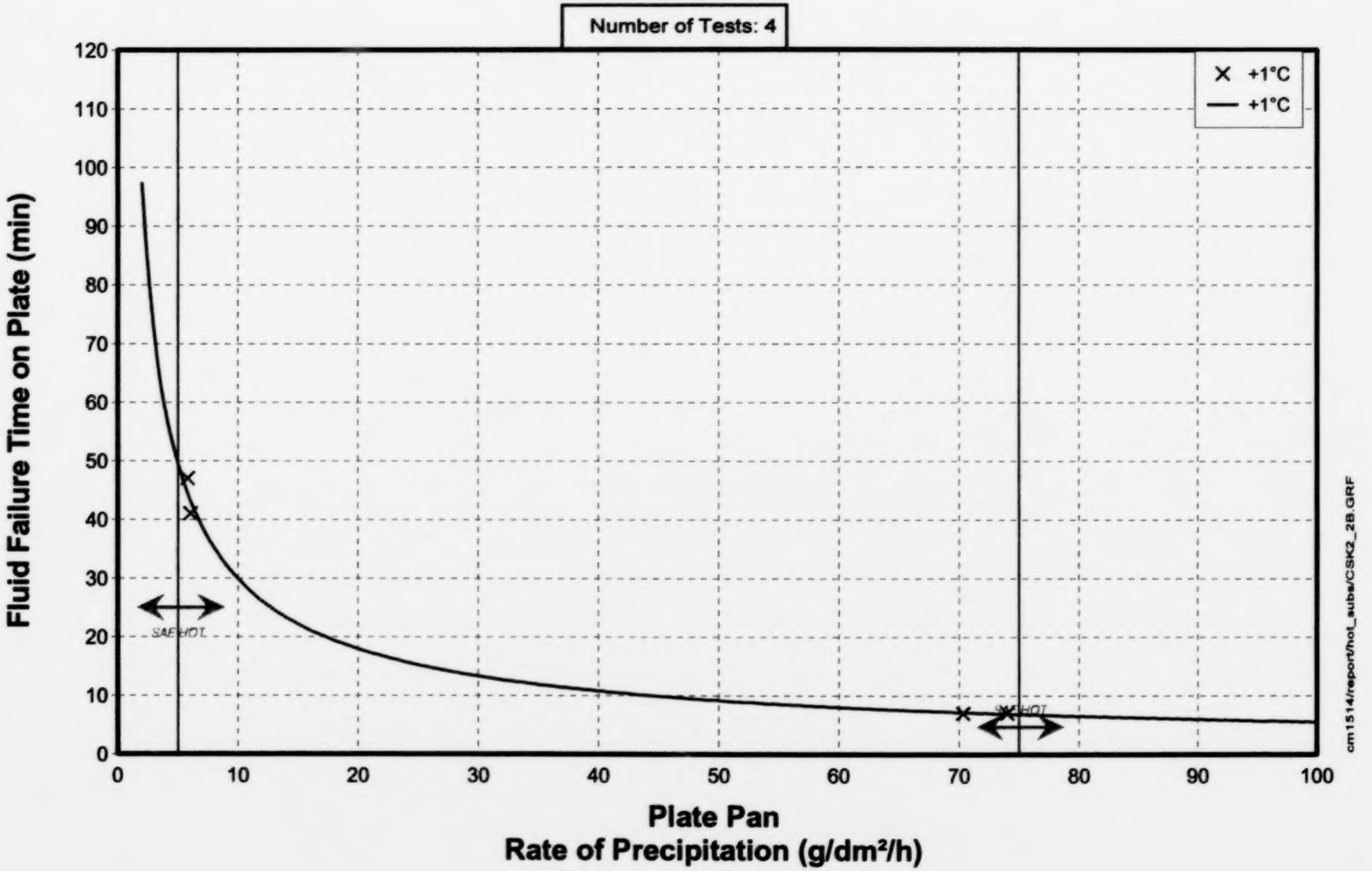


FIGURE 5.41
EFFECT OF RATE OF PRECIPITATION ON ENDURANCE TIME
KILFROST ABC-II PLUS 75/25
RAIN ON COLD-SOAKED SURFACE
1998-99



5.4 Type I Fluid Holdover Time Tests

Type I fluids are deicing fluids. They are not rheologically modified fluids, but rather exhibit Newtonian fluid properties. Type I fluids are used primarily to remove ice and snow from aircraft surfaces. They are applied at high pressures and elevated temperatures. These fluids do not offer the extended protection of thickened fluids, so depending on weather conditions, anticipated taxi-times, or other pre-takeoff delays, an operator can choose to extend the time of fluid protection by application of Type II or Type IV anti-icing fluid on top of the Type I fluid.

Although the Type I holdover time table has been substantiated by tests conducted in previous years, several new Type I fluids became available during the past year. Holdover time testing of these new fluids was conducted at NRC's CEF in July 1999. Tests were performed using fluids diluted to a 10°C buffer.

Holdover time testing with these new fluids was conducted to allow the new fluids to be included in upcoming FAA and Transport Canada lists of certified fluids. Two control or reference fluids, Union Carbide ADF and Octagon Octaflo, were tested alongside the new fluids to ensure that the holdover time results of the new fluids resembled those of certified ethylene and propylene glycol-based Type I fluids. Because testing could not be conducted in natural snow conditions in July, use of the prototype NCAR artificial snow generation system was approved for snow testing. It was understood that testing of the same fluids in natural snow would take place the following winter test season.

Table 5.4 shows the Type I fluids used in testing. A significant amount of time was required to prepare the various samples required for testing. Since fluids needed to be diluted, freeze point curves (dilution curves) and lowest operational use temperatures (LOUT) were obtained for each fluid. The freeze point curves used appear in Appendix T. Fluid concentrations were lowered by adding hard water and the resultant freeze points were verified using calibrated Brix-scale refractometers.

Type I tests were carried out at three temperatures: +1°C, -10°C and -30°C. Because testing required fluids diluted to a 10°C buffer, fluid samples were prepared with freeze points of -9°C, -20°C, and -40°C. Attempts were made to conduct tests at the LOUT for each fluid. Due to procedural and logistics problems, and complications related to maintaining chamber capabilities at extreme cold temperatures, -30°C was chosen as the test temperature in cold conditions. No holdover time fluctuations were anticipated by the use of -30°C as the LOUT, due to the 10°C buffer. Table 5.5 contains the necessary information for the preparation of the diluted fluid samples.

TABLE 5.4

TYPE I FLUIDS USED IN HOLDOVER TIME TESTING

Manufacturer	Fluid	Formulation	New or Reference Fluid
Clariant	EG I 1996	Ethylene	New
Home Oil	Safetemp	Propylene	New
Inland	Duragly-P	Propylene	New
Jarchem	Jarkleer	Propylene	New
Kilfrost	DF Plus	Propylene	New
Octagon	Octaflo	Propylene	Reference
Octagon	Octaflo EF	Propylene	New
Union Carbide	ADF	Ethylene	Reference

TABLE 5.5
FLUID MIXTURES FOR TYPE I TESTS

Fluid(1)	Brix of Sample Sent	CSW Test Temp (°C)	CSW FP Temp (°C)	CSW Volume of Fluid (%)	CSW Brix	LOUT Test Temp (°C)	LOUT FP Temp (°C)	LOUT Volume	LOUT Brix	-10°C Test Temp (°C)	-10°C FP Temp (°C)	-10°C Volume	-10°C Brix
UCAR ADF	52	1	-9	21.5	13.5	-30	-40	54	32	-10	-20	36	22.5
Home Oil	53	1	-9	27.5	19	-30	-40	60	37	-10	-20	43	28
Jarchem	49.5	1	-9	26.5	17.25	-30	-40	64	38.25	-10	-20	41	26.5
Octaflo	>50	1	-9	27.5	18.5	-30	-40	60	37	-10	-20	42	27
Octaflo EF	>50	1	-9	27.5	18.5	-30	-40	60	37	-10	-20	42	27
Kilfrost	49.5	1	-9	28.5	17.5	-30	-40	68	38	-10	-20	48.5	28.5
Clariant	46.5	1	-9	28	14	-30	-40	66	33.5	-10	-20	45	22.5
Inland	>50	1	-9	30	21.2	-30	-40	60	37	-10	-20	42	27.2

(1) Concentrate.

Additional testing of Type I fluids in standard concentrations (ready-to-use) was conducted in natural and simulated conditions in 1998-99. Tests with standard dilution Type I fluids were performed alongside Inland recycled fluids to compare the holdover time performances of the various fluids. These tests are described in detail in Section 6.

The data from the Type fluid I tests (diluted to a 10°C buffer) conducted in 1998-99 are shown in Figures 5.42 to 5.47. For clarity, the regression curves for each of the Type I fluids have been omitted. It is important to note, however, that the regression method of analysis was used to determine the holdover times of the Type I fluids. The figures for each individual fluid, including the regression curves, appear in Appendix P.

Each manufacturer was also required to send samples of the fluid provided to APS for holdover time test purposes to AMIL for WSET testing. Following the conduct of the holdover time tests at NRC in Ottawa, APS was informed that two fluids, Jarchem Jarkleer and Clariant EG I 1996, did not meet the minimum WSET requirements. The Jarchem product was subsequently reformulated and did pass the WSET.

5.4.1 Freezing Drizzle

The following is a cell-by-cell summary of the holdover time performance of all Type I fluid brands tested under conditions of simulated freezing drizzle. The results are arranged in the sequence of temperature ranges (from top to bottom) that appear in the corresponding columns of the holdover time tables. Because it was not possible to simulate freezing drizzle above 0°C, the holdover time results for this category of precipitation above 0°C are identical to those in the range of 0°C to -10°C.

5.4.1.1 Type I Fluid Holdover Times for Freezing Drizzle

i. Type I diluted fluid, above 0°C and 0°C to -10°C, freezing drizzle (Figure 5.42)

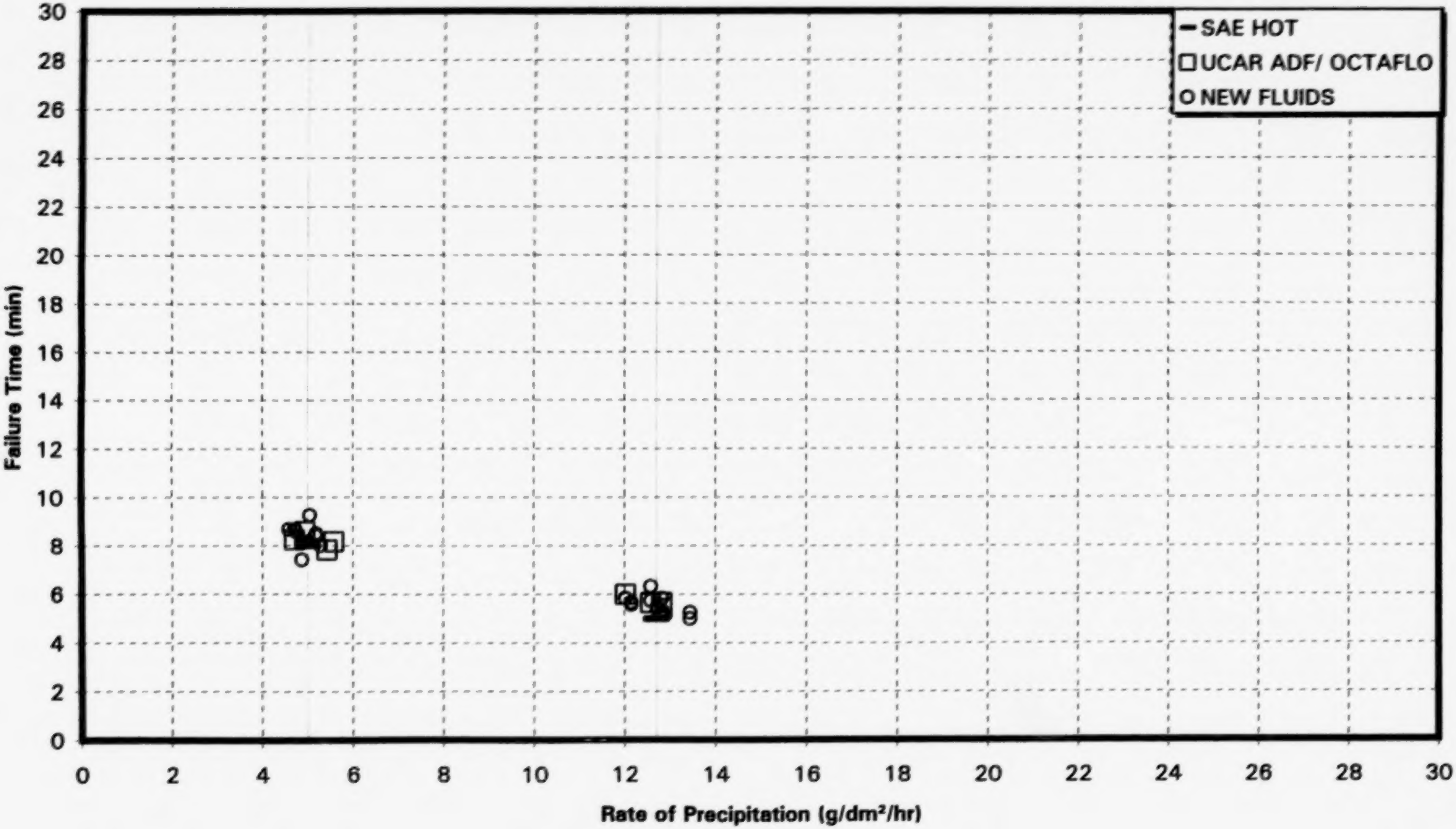
   The SAE holdover times of 5 to 8 minutes in these cells are appropriate, based on the results of the recent Type I tests. All of the new type I fluids exhibit similar holdover times to the reference fluids as well as to the other new Type I fluids.

FIGURE 5.42

EFFECT OF RATE OF PRECIPITATION ON ENDURANCE TIME

TYPE I DEICING FLUIDS

SIMULATED FREEZING DRIZZLE AT -10°C



cm1514/report/hot_subs/Figure 5.42-47
At: ZD

5.4.2 Light Freezing Rain

The following is a cell-by-cell summary of the holdover time performance of the new Type I fluids tested under conditions of simulated light freezing rain. Because it was not possible to simulate freezing precipitation above 0°C, the holdover time results for this category of precipitation above 0°C are identical to those in the range of 0°C to -10°C.

5.4.2.1 Type I Fluid Holdover Times for Light Freezing Rain

i) Type I diluted fluid, above 0°C and 0 to -10°C, light freezing rain (Figure 5.43)

The SAE holdover times of 2 to 5 minutes in these cells are appropriate, based on the results of the recent Type I tests. All of the new type I fluids exhibit similar holdover times to the reference fluids as well as to the other new Type I fluids.

5.4.3 Freezing Fog

The freezing fog category is divided into three cells. The data were collected under precipitation rates of 2 and 5 g/dm^2/h. Tests conducted prior to 1998-99 did not use the lower precipitation rate limit of 2 g/dm^2/h, and as such, the upper holdover time limits of the Type I SAE table in freezing fog may need to be re-adjusted.

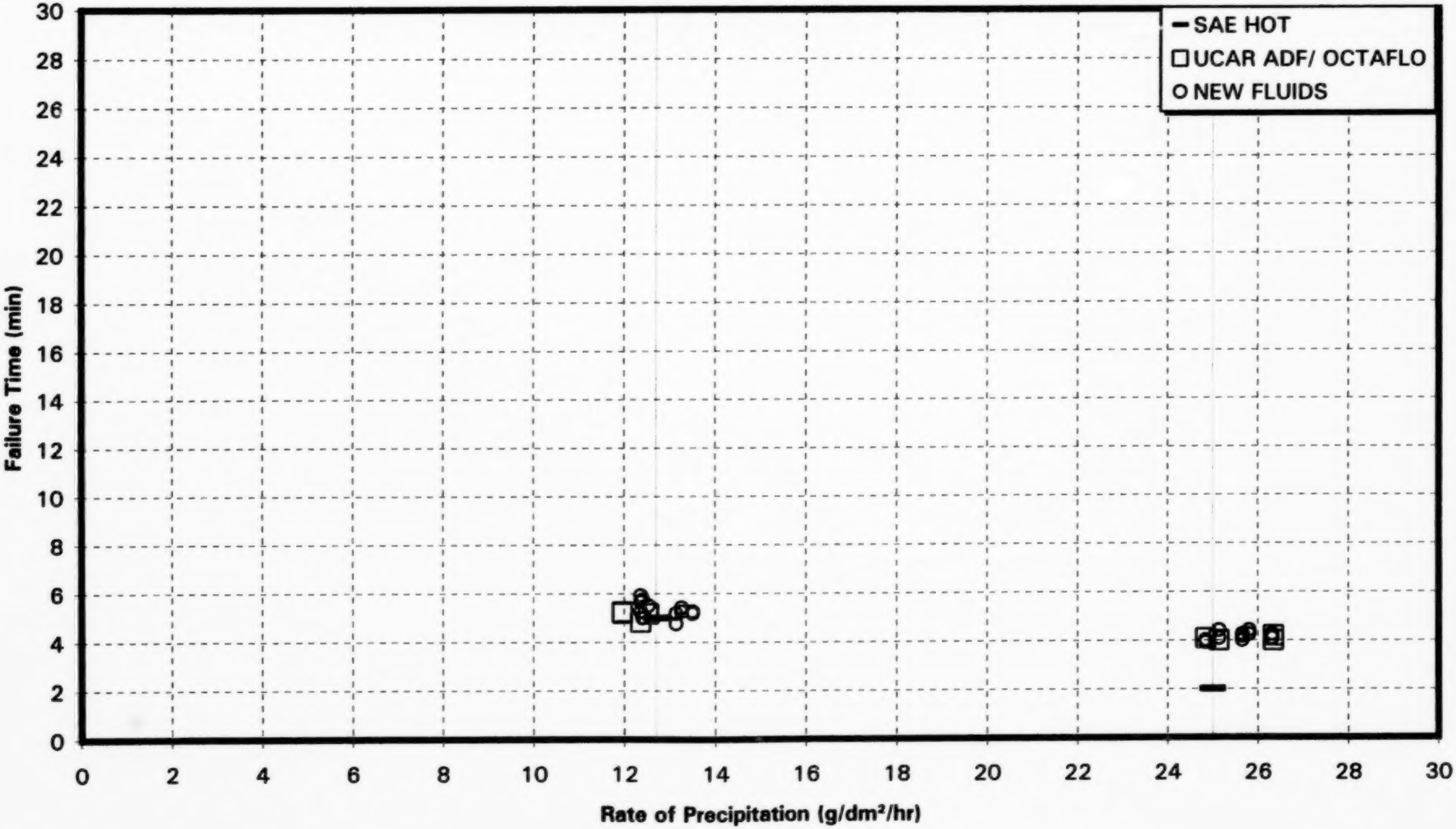
Failure times were measured at two temperatures, -10°C, and -30°C. Although it was not possible to create freezing fog at temperatures above 0°C, the holdover times in the Type I holdover time tables are different in the two temperature ranges, above 0°C and 0°C to -10°C.

FIGURE 5.43

EFFECT OF RATE OF PRECIPITATION ON ENDURANCE TIME

TYPE I DEICING FLUIDS

SIMULATED LIGHT FREEZING RAIN AT -10°C



cm1514/report/hot_subs/Figure 5.42-47
At: ZR

5.4.3.1 Type I Fluid Holdover Times for Freezing Fog

i) Type I diluted fluid, above 0°C, freezing fog

No testing was conducted during the past year in this temperature range, since it was not possible to generate freezing fog at temperatures above 0°C.

ii) Type I diluted fluid, 0°C to -10°C, freezing fog (Figure 5.44)

The lower SAE holdover time for Type I fluids is appropriate. All of the new fluids, as well as the two reference fluids, exhibit similar holdover time performance at the 5 g/dm^2/h precipitation rate. The upper holdover times of all the Type I fluids, including the two reference fluids, are below the upper SAE holdover time value. It is noteworthy that these tests constitute the first freezing fog tests conducted using dilute Type I fluids at a rate of 2 g/dm^2/h. This value may need to be re-adjusted, as was the case with Type IV fluids.

iii) Type I diluted fluid, -30°C, freezing fog (Figure 5.45)

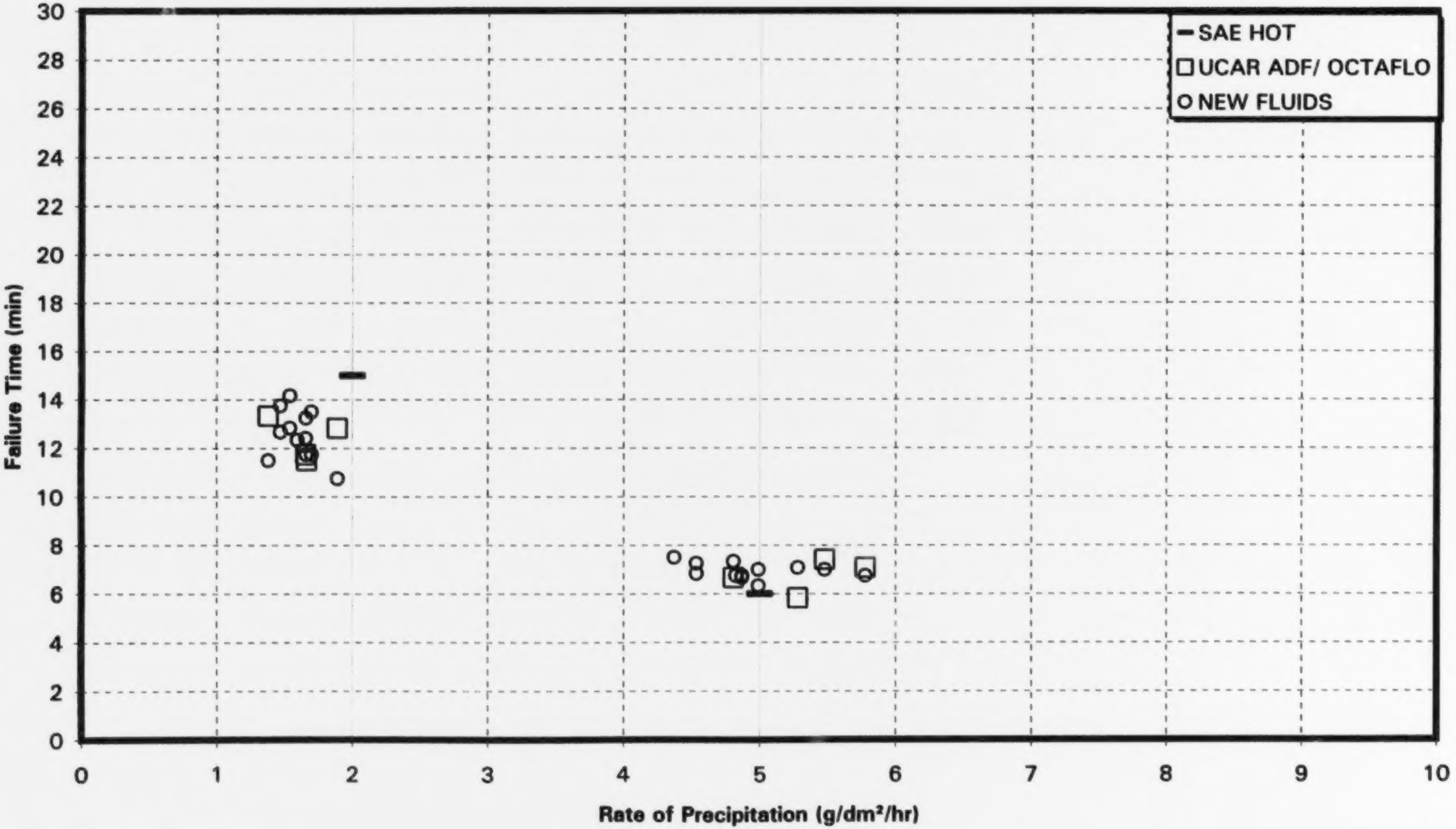
The lower SAE holdover time for Type I fluids is appropriate. All of the new fluids, as well as the two reference fluids, exhibit similar performance at the 5 g/dm^2/h precipitation rate. The upper holdover times of all the Type I fluids, including the two reference fluids, are below the upper SAE holdover time value. It is noteworthy that these tests constitute the first freezing fog tests conducted using dilute Type I fluids at a rate of 2 g/dm^2/h. This value may need to be re-adjusted, as was the case with Type IV fluids.

FIGURE 5.44

EFFECT OF RATE OF PRECIPITATION ON ENDURANCE TIME

TYPE I DEICING FLUIDS

SIMULATED FREEZING FOG AT -10°C



cm1514/report/hot_subs/Figure 5.42-47
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Final Draft 1.0, November 05

5.4.4 Rain on a Cold-Soaked Wing

The data used to evaluate the holdover times for this category of precipitation covered precipitation rates ranging from 5 g/dm^2/h to 76 g/dm^2/h. This encompasses heavy drizzle (5 to 12.7 g/dm^2/h), light rain (12.7 to 25 g/dm^2/h), and moderate rain (25 to 76 g/dm^2/h). The cold-soak test boxes were 7.5 cm deep. Dimensional details are described in Section 2. The box temperature prior to the start of testing was -10°C.

5.4.4.1 Type I Fluid Holdover Times for Rain on a Cold-Soaked Wing

i. Type I diluted fluid, 1°C, rain on a cold-soaked wing (Figure 5.46)

The SAE holdover time of 2 to 5 minutes in this cell is appropriate, based on the results of the recent Type I tests. All of the new Type I fluids exhibit similar holdover times when compared to the reference fluids and to the other new Type I fluids.

5.4.5 Simulated Snow

Simulated snow tests were conducted at NRC's CEF using a prototype artificial snow generation system developed by NCAR.

The snow category of the Type I holdover time table is divided into three cells: above 0°C, 0°C to -10°C, and below -10°C. The data used to evaluate the holdover times for this category of precipitation covered precipitation rates ranging from 10 g/dm^2/h to 25 g/dm^2/h. Tests were conducted only at -10°C, due to difficulties with the system at cold temperatures.

FIGURE 5.45

EFFECT OF RATE OF PRECIPITATION ON ENDURANCE TIME

TYPE I DEICING FLUIDS

SIMULATED FREEZING FOG AT -30°C

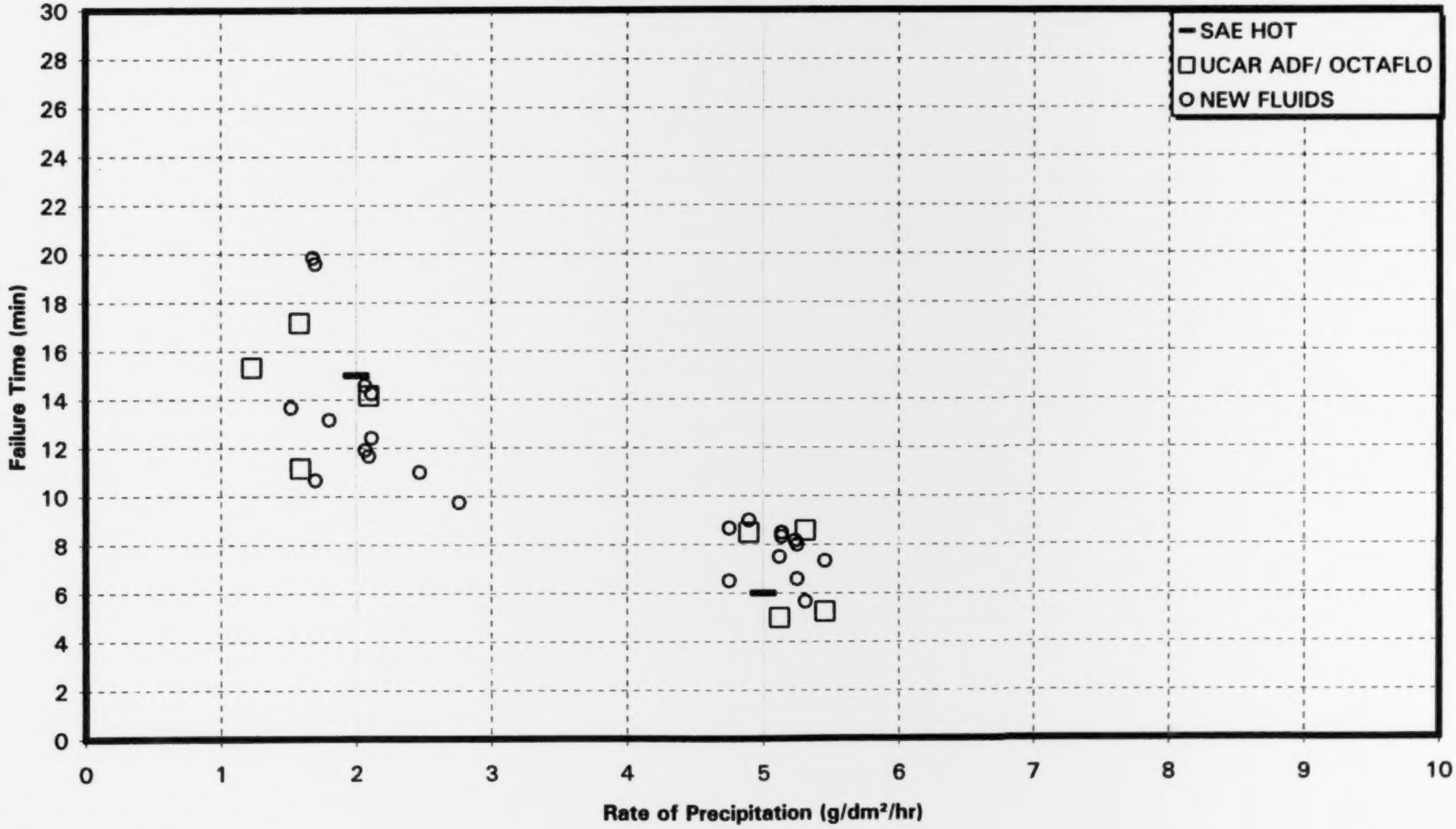
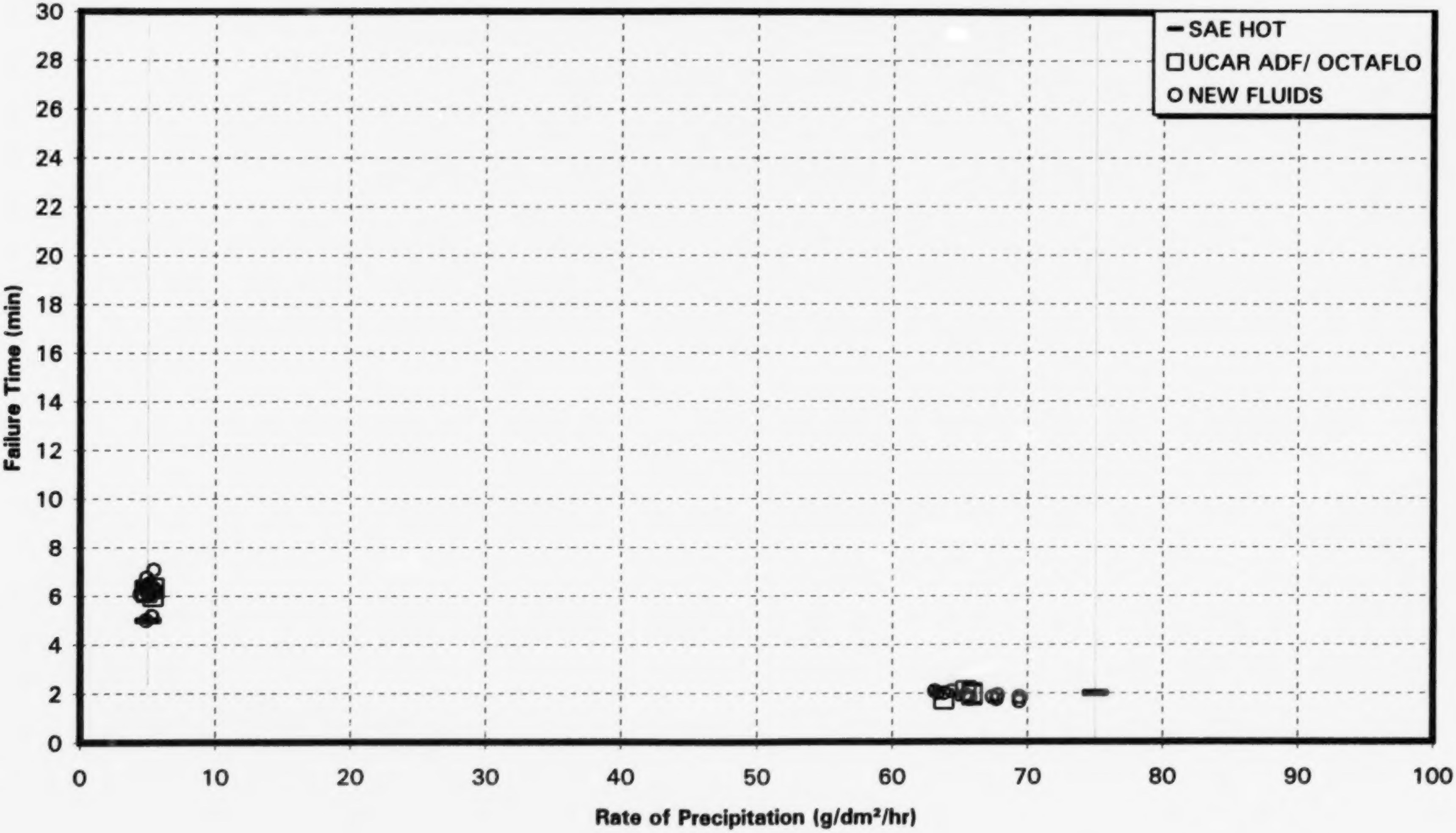


FIGURE 5.46

EFFECT OF RATE OF PRECIPITATION ON ENDURANCE TIME

TYPE I DEICING FLUIDS

RAIN ON COLD-SOAK SURFACE



cm1514/report/hot_subs/Figure 5.42-47
At: CS
Final Draft 1.0, November 05

5.4.5.1 Type I Fluid Holdover Times for Simulated Snow

i. Type I diluted fluid, above 0°C and 0°C to -10°C, simulated snow (Figure 5.47)

The results obtained with the NCAR artificial snow generation system were well below those of the SAE Type I holdover time table in snow. Due to the current precipitation rate control deficiencies of the system, the majority of tests were conducted outside of the desired rates of 10 g/dm^2/h and 25 g/dm^2/h. Modifications to the current system will be required in order to conduct any future testing. It is also suggested that the new Type I fluids be tested in natural snow conditions during the upcoming winter test season.

The deficiencies of the NCAR artificial snow generation and recommendations for improvement of the system are outlined in Transport Canada report TP 13488E (11).

5.4.6 Overall Perspective on Type I Results

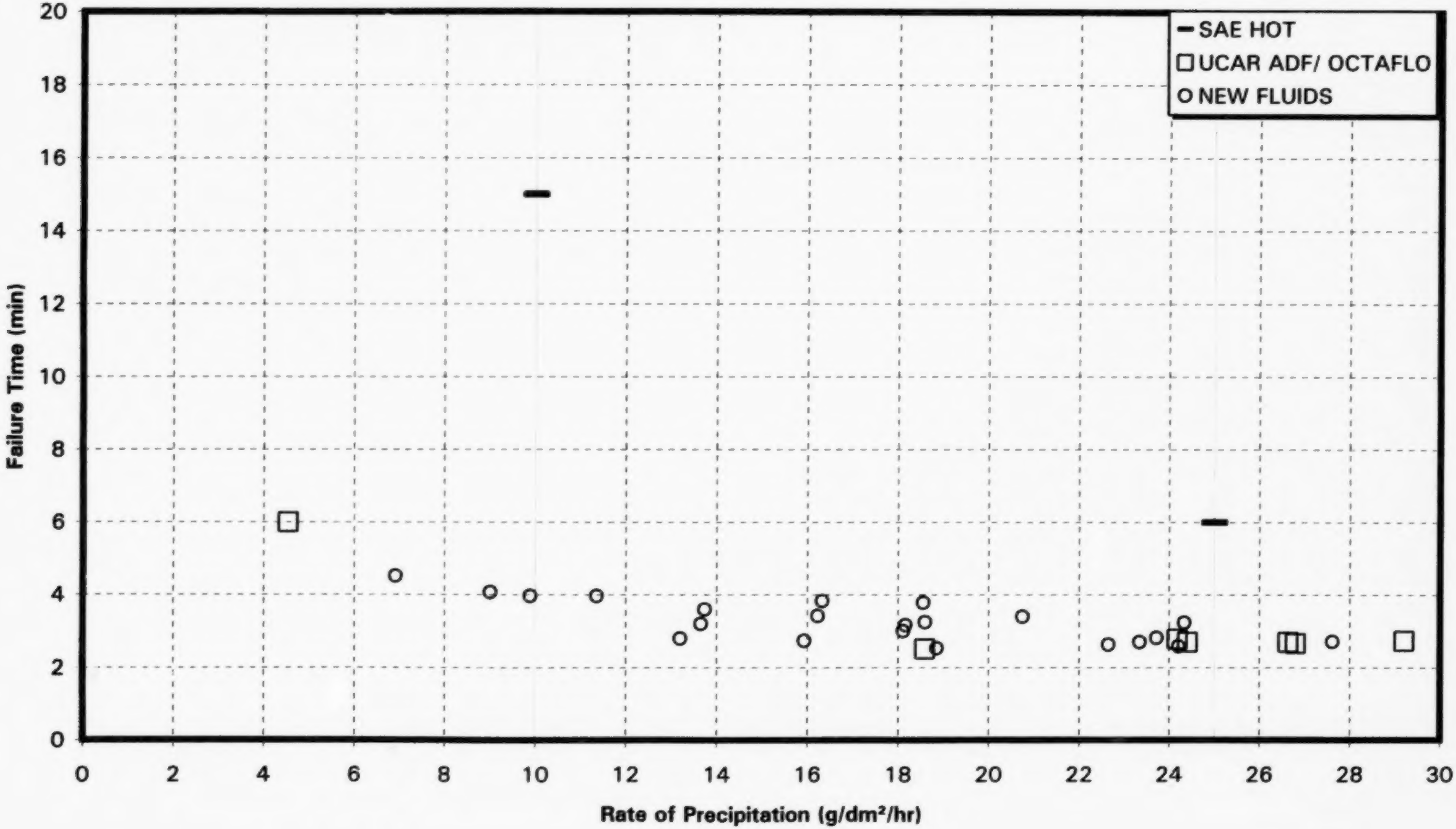
In general, the Type I holdover time results agreed with the current SAE Type I holdover time guidelines. The upper values in freezing fog may need to be re-adjusted, due to the fact that a specific precipitation rate of 2 g/dm^2/h was used for the first time in holdover time testing. The results obtained in simulated snow were inconclusive, due to deficiencies in the functioning of the prototype artificial snow generation system. It is noteworthy that this method has not yet been approved for use for the determination of fluid holdover times in snow.

FIGURE 5.47

EFFECT OF RATE OF PRECIPITATION ON ENDURANCE TIME

TYPE I DEICING FLUIDS

SIMULATED SNOW AT -10°C



5.5 Type III Fluid

Type III fluid is a thickened anti-icing fluid that exhibits shear, flow, and anti-icing properties that lie between Type I and Type IV fluids. The fluid was specifically designed for use on aircraft with lower rotation speeds.

The earliest holdover time tests with Type III fluid were carried out during the 1991/92 test season (see Transport Canada report TP 11454E (12)). The next series of Type III fluid tests, conducted during the 1992/93 test season, are documented in Transport Canada report TP 11836E (13). These data are somewhat obsolete as the fluid tested is no longer commercially available. Type II fluids were tested during the 1993-94 test season, and the results summary was reported in TC report TP 12915E (14). The Type III fluid data for Transport Canada report TP 11836E (13) were combined with 75/25 Type IV fluid data and provided the basis for a proposed Type III fluid holdover time table, which first appeared in Transport Canada report, TP 12896E (15).

The latest Type III fluid test data were acquired during the 1996-97 test season, using one fluid from one fluid manufacturer. The Type III fluid data were subject to the same regression method of analysis used to determine holdover times for Type IV fluids. The Type III fluid used in the 1996-97 holdover time tests has since been removed from the market (8).

No Type III fluids were available during the past test season, and therefore no testing of Type III fluids was performed by APS. A Type III holdover time table does exist; however, no qualified Type III fluids are currently available. The values in the Type III table would need to be substantiated if new fluids became available in the future.

5.6 Official Holdover Time Tables for 1999-2000

The SAE officially accepted holdover time tables for Type I, Type II, and Type IV fluids are presented here. These tables are proposed for worldwide use during the 1999-2000 winter season.

After much discussion at the SAE G-12 Holdover Time Subcommittee meeting in Toronto, an additional column was added to the holdover time tables for 1999-2000, covering the precipitation conditions of heavy snow, snow pellets, snow grains, ice pellets, moderate and heavy freezing rain, and hail. A cautionary note, stating that no holdover time guidelines exist for these conditions, has been placed in this column.

In addition, the viscosity of the fluid sample used in holdover time testing, as measured by APS personnel, now appears on the fluid-specific holdover time table for any given anti-icing fluid. The instrument spindle, chamber size, temperature and RPM are also documented, along with the viscosity measurement. In order for the fluid-specific values of a fluid to be valid, operators must ensure that the viscosity of the fluid used is superior to the published viscosity of that fluid, using the same viscosity measurement method published.

Table 5.6 is the accepted holdover time table for SAE Type I fluids. It is the result of material presented in Subsection 5.4.

Table 5.7 is the accepted holdover time table for SAE Type II fluids. It is the result of material presented in Subsection 5.3. The fluid-specific holdover time table for Kilfrost ABC-II Plus is shown in Table 5.8.

There are seven Type IV fluid holdover time tables. The first, Table 5.9, is the new SAE Type IV fluid holdover time table. Tables 5.10 to 5.15 are the fluid-specific Type IV holdover time tables and correspond to Clariant MPIV 1957, Clariant MPIV 2001, Kilfrost ABC-S, Octagon Max-Flight, SPCA AD-480, and Union Carbide Ultra + fluids, respectively. These tables result from the material presented in Subsection 5.2.

The Transport Canada and FAA versions of the SAE holdover time tables are found in Appendix H. This section includes the same tables, but in a format that facilitates viewing of the individual holdover time cells. This format contains only a small portion of the notes listed at the bottom of the tables intended for official use.

TABLE 5.6

SAE TYPE I HOLDOVER TIMES

For Use in 1999-2000

OAT		Approximate Holdover Times Under Various Weather Conditions (hours:minutes)						
°C	°F	*FROST	FREEZING FOG	SNOW	**FREEZING DRIZZLE	LIGHT FRZ RAIN	RAIN ON COLD SOAKED WING	OTHER***
above 0°	above 32°	0:45	0:12-0:30	0:06-0:15	0:05-0:08	0:02-0:05	0:02-0:05	
0 to -10	32 to 14	0:45	0:06-0:15	0:06-0:15	0:05-0:08	0:02-0:05	**CAUTION No holdover time guidelines exist**	
below -10	below 14	0:45	0:06-0:15	0:06-0:15				

* During conditions that apply to aircraft protection for ACTIVE FROST.

** Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.

*** Heavy snow, snow pellets, snow grains, ice pellets, moderate and heavy freezing rain, and hail.

TABLE 5.7

SAE TYPE II HOLDOVER TIMES

For Use in 1999-2000

OAT		SAE Type II Fluid Concentration Neat-Fluid/Water (Vol%/Vol%)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)						
°C	°F		*FROST	FREEZING FOG	SNOW	***FREEZING DRIZZLE	LIGHT FRZ RAIN	RAIN ON COLD SOAKED WING	OTHER****
above 0°	above 32°	100/0	12:00	1:05-2:15	0:20-1:00	0:30-1:00	0:15-0:30	0:05-0:40	**CAUTION No holdover time guidelines exist**
		75/25	6:00	0:50-1:45	0:15-0:40	0:20-0:45	0:10-0:25	0:05-0:25	
		50/50	4:00	0:15-0:35	0:05-0:15	0:05-0:20	0:05-0:10		
0 to -3	32 to 27	100/0	8:00	0:35-1:30	0:20-0:45	0:30-1:00	0:15-0:30		
		75/25	5:00	0:25-1:00	0:15-0:30	0:20-0:45	0:10-0:25		
		50/50	3:00	0:15-0:35	0:05-0:15	0:05-0:20	0:05-0:10		
below -3 to -14	below 27 to 7	100/0	8:00	0:30-1:05	0:15-0:35	**0:15-0:45	**0:10-0:30		
		75/25	5:00	0:20-0:55	0:15-0:25	**0:15-0:30	**0:10-0:20		
below -14 to -25	below 7 to -13	100/0	8:00	0:15-0:20	0:15-0:30				
below -25	below -13	100/0	SAE TYPE II fluid may be used below -25°C (-13°F) provided the freezing point of the fluid is at least 7°C (13°F) below the OAT and the aerodynamic acceptance criteria are met. Consider use of SAE Type I when SAE Type II fluid cannot be used.						

* During conditions that apply to aircraft protection for ACTIVE FROST.

** The lowest use temperature is limited to -10°C (14°F).

*** Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.

**** Heavy snow, snow pellets, snow grains, ice pellets, moderate and heavy freezing rain, and hail.

TABLE 5.8

"*FLUID-SPECIFIC*" TYPE II HOLDOVER TIMES FOR 1999-2000

KILFROST ABC-II PLUS

Viscosity of Neat 100% Fluid Tested 3,600 cp

20°C, 0.3 RPM, Spindle LV2, 250 ml beaker, 150 ml fluid, 10 min, grd.leg

OAT		Type II Fluid Concentration Neat-Fluid/Water (% by volume)	Approximate Holdover Times Anticipated Under Various Weather Conditions (hours:minutes)						
°C	°F		*FROST	FREEZING FOG	SNOW	***FREEZING DRIZZLE	LIGHT FRZ RAIN	RAIN ON COLD SOAKED WING	OTHER****
above 0°	above 32°	100/0	12:00	1:10-2:25	0:35-1:20	0:35-1:10	0:30-0:40	0:05-1:00	CAUTION No holdover time guidelines exist
		75/25	6:00	1:10-2:25	0:35-1:10	0:30-1:00	0:20-0:40	0:05-0:50	
		50/50	4:00	0:15-0:45	0:20-0:40	0:05-0:25	0:05-0:15		
0 to -3	32 to 27	100/0	8:00	1:10-2:25	0:25-0:55	0:35-1:10	0:30-0:40		
		75/25	5:00	1:10-2:25	0:25-0:50	0:30-1:00	0:20-0:40		
		50/50	3:00	0:15-0:45	0:15-0:35	0:05-0:25	0:05-0:15		
below -3 to -14	below 27 to 7	100/0	8:00	0:30-1:05	0:15-0:35	**0:15-0:45	**0:10-0:30		
		75/25	5:00	0:20-0:55	0:15-0:35	**0:15-0:30	**0:10-0:20		
below -14 to -25	below 7 to -13	100/0	8:00	0:15-0:20	0:15-0:30				
below -25	below -13	100/0	SAE TYPE II fluid may be used below -25ºC (-13ºF) provided the freezing point of the fluid is at least 7ºC (13ºF) below the OAT and the aerodynamic acceptance criteria are met. Consider use of SAE Type I when SAE Type II fluid cannot be used.						

* During conditions that apply to aircraft protection for ACTIVE FROST.

** The lowest use temperature is limited to -10ºC (14ºF).

*** Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.

**** Heavy snow, snow pellets, snow grains, ice pellets, moderate and heavy freezing rain, and hail.

TABLE 5.9

SAE TYPE IV HOLDOVER TIMES

For Use in 1999-2000

OAT		Type IV Fluid Concentration Neat-Fluid/Water (% by volume)	Approximate Holdover Times Anticipated Under Various Weather Conditions (hours:minutes)						
°C	°F		*FROST	FREEZING FOG	SNOW	***FREEZING DRIZZLE	LIGHT FRZ RAIN	RAIN ON COLD SOAKED WING	OTHER****
above 0°	above 32°	100/0	18:00	1:05-2:15	0:35-1:05	0:40-1:00	0:25-0:40	0:10-0:50	**CAUTION No holdover time guidelines exist**
		75/25	6:00	1:05-1:45	0:20-0:40	0:30-1:00	0:15-0:30	0:05-0:35	
		50/50	4:00	0:20-0:35	0:05-0:20	0:10-0:20	0:05-0:10		
0 to -3	32 to 27	100/0	12:00	1:05-2:15	0:30-0:55	0:40-1:00	0:25-0:40		
		75/25	5:00	1:05-1:45	0:20-0:35	0:30-1:00	0:15-0:30		
		50/50	3:00	0:20-0:35	0:05-0:15	0:10-0:20	0:05-0:10		
below -3 to -14	below 27 to 7	100/0	12:00	0:40-1:30	0:20-0:40	**0:20-0:55	**0:10-0:30		
		75/25	5:00	0:25-1:00	0:15-0:25	**0:20-0:55	**0:10-0:30		
below -14 to -25	below 7 to -13	100/0	12:00	0:20-0:40	0:15-0:30				
below -25	below -13	100/0	SAE TYPE IV fluid may be used below -25°C (-13°F) provided the freezing point of the fluid is at least 7°C (13°F) below the OAT and the aerodynamic acceptance criteria are met. Consider use of SAE Type I when SAE Type IV fluid cannot be used.						

* During conditions that apply to aircraft protection for ACTIVE FROST.

** The lowest use temperature is limited to -10°C (14°F).

*** Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.

**** Heavy snow, snow pellets, snow grains, ice pellets, moderate and heavy freezing rain, and hail.

TABLE 5.10
"*FLUID-SPECIFIC*" TYPE IV HOLDOVER TIMES FOR 1999-2000
CLARIANT SAFEWING MPIV 1957
Viscosity of Neat 100% Fluid Tested 16,200 cP
20°C, 0.3 RPM, Spindle SC4-34/13R, 10 ml fluid, 15 min

OAT		Type IV Fluid Concentration	Approximate Holdover Times Anticipated Under Various Weather Conditions (hours:minutes)						
°C	°F	Neat-Fluid/Water (% by volume)	*FROST	FREEZING FOG	SNOW	***FREEZING DRIZZLE	LIGHT FRZ RAIN	RAIN ON COLD SOAKED WING	OTHER****
above 0°	above 32°	100/0	18:00	1:05-2:15	0:35-1:05	0:40-1:10	0:30-0:45	0:15-1:10	
		75/25	6:00	1:10-2:10	0:35-1:05	0:35-1:05	0:25-0:40	0:10-1:00	
		50/50	4:00	0:25-0:50	0:15-0:30	0:15-0:25	0:05-0:15	CAUTION No holdover time guidelines exist	
0 to -3	32 to 27	100/0	12:00	1:05-2:15	0:30-0:55	0:40-1:10	0:30-0:45		
		75/25	5:00	1:10-2:10	0:30-0:50	0:35-1:05	0:25-0:40		
		50/50	3:00	0:25-0:50	0:10-0:20	0:15-0:25	0:05-0:15		
below -3 to -14	below 27 to 7	100/0	12:00	0:45-1:30	0:30-0:50	**0:35-0:55	**0:20-0:35		
		75/25	5:00	0:25-1:10	0:20-0:40	**0:25-0:55	**0:15-0:30		
below -14 to -25	below 7 to -13	100/0	12:00	0:25-0:40	0:25-0:45				
below -25	below -13	100/0	SAE TYPE IV fluid may be used below -25°C (-13°F) provided the freezing point of the fluid is at least 7°C (13°F) below the OAT and the aerodynamic acceptance criteria are met. Consider use of SAE Type I when SAE Type IV fluid cannot be used.						

* During conditions that apply to aircraft protection for ACTIVE FROST.

** The lowest use temperature is limited to -10°C (14°F).

*** Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.

**** Heavy snow, snow pellets, snow grains, ice pellets, moderate and heavy freezing rain, and hail.

TABLE 5.11

"*FLUID-SPECIFIC*" TYPE IV HOLDOVER TIMES FOR 1999-2000

CLARIANT SAFEWING MPIV 2001

Viscosity of Neat 100% Fluid Tested 18,000 cp

20°C, 0.3 RPM, Spindle SC4-34/13R, 10 ml fluid, 15 min

OAT		Type IV Fluid Concentration Neat-Fluid/Water (% by volume)	Approximate Holdover Times Anticipated Under Various Weather Conditions (hours:minutes)						
°C	°F		*FROST	FREEZING FOG	SNOW	***FREEZING DRIZZLE	LIGHT FRZ RAIN	RAIN ON COLD SOAKED WING	OTHER****
above 0°	above 32°	100/0	18:00	1:05-2:15	1:55-2:00	0:55-1:55	0:40-1:00	0:15-1:55	CAUTION No holdover time guidelines exist
		75/25	6:00	1:05-1:45	0:50-1:25	0:35-1:10	0:25-0:35	0:05-0:55	
		50/50	4:00	0:20-0:35	0:10-0:20	0:10-0:20	0:05-0:15		
0 to -3	32 to 27	100/0	12:00	1:05-2:15	1:00-1:55	0:55-1:55	0:40-1:00		
		75/25	5:00	1:05-1:45	0:35-1:00	0:35-1:10	0:25-0:35		
		50/50	3:00	0:20-0:35	0:10-0:20	0:10-0:20	0:05-0:15		
below -3 to -14	below 27 to 7	100/0	12:00	0:40-1:30	0:30-0:50	**0:55-1:35	**0:30-0:45		
		75/25	5:00	0:25-1:00	0:20-0:35	**0:40-1:10	**0:20-0:30		
below -14 to -25	below 7 to -13	100/0	12:00	0:20-0:40	0:20-0:35				
below -25	below -13	100/0	SAE TYPE IV fluid may be used below -25°C (-13°F) provided the freezing point of the fluid is at least 7°C (13°F) below the OAT and the aerodynamic acceptance criteria are met. Consider use of SAE Type I when SAE Type IV fluid cannot be used.						

* During conditions that apply to aircraft protection for ACTIVE FROST.

** The lowest use temperature is limited to -10°C (14°F).

*** Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.

**** Heavy snow, snow pellets, snow grains, ice pellets, moderate and heavy freezing rain, and hail.

TABLE 5.12

"*FLUID-SPECIFIC*" TYPE IV HOLDOVER TIMES FOR 1999-2000

KILFROST ABC-S

Viscosity of Fluid Tested 17,000 cp

20°C, 0.3 RPM, Spindle LV2, 150 ml beaker, 150 ml fluid, 10 min, grd.leg

OAT		Type IV Fluid Concentration Neat-Fluid/Water (% by volume)	Approximate Holdover Times Anticipated Under Various Weather Conditions (hours:minutes)						
°C	°F		*FROST	FREEZING FOG	SNOW	***FREEZING DRIZZLE	LIGHT FRZ RAIN	RAIN ON COLD SOAKED WING	OTHER****
above 0°	above 32°	100/0	18:00	2:35-4:00	1:10-2:00	1:20-1:50	1:00-1:25	0:20-1:15	CAUTION No holdover time guidelines exist
		75/25	6:00	1:05-1:45	0:30-1:05	0:45-1:10	0:35-0:50	0:10-0:50	
		50/50	4:00	0:20-0:35	0:05-0:20	0:15-0:20	0:05-0:10		
0 to -3	32 to 27	100/0	12:00	2:35-4:00	1:00-1:40	1:20-1:50	1:00-1:25		
		75/25	5:00	1:05-1:45	0:30-0:55	0:45-1:10	0:35-0:50		
		50/50	3:00	0:20-0:35	0:05-0:15	0:15-0:20	0:05-0:10		
below -3 to -14	below 27 to 7	100/0	12:00	0:45-2:05	0:45-1:20	**0:20-1:00	**0:10-0:30		
		75/25	5:00	0:25-1:00	0:25-0:50	**0:20-1:10	**0:10-0:35		
below -14 to -25	below 7 to -13	100/0	12:00	0:20-0:40	0:40-1:10				
below -25	below -13	100/0	SAE TYPE IV fluid may be used below -25°C (-13°F) provided the freezing point of the fluid is at least 7°C (13°F) below the OAT and the aerodynamic acceptance criteria are met. Consider use of SAE Type I when SAE Type IV fluid cannot be used.						

* During conditions that apply to aircraft protection for ACTIVE FROST.

** The lowest use temperature is limited to -10°C (14°F).

*** Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.

**** Heavy snow, snow pellets, snow grains, ice pellets, moderate and heavy freezing rain, and hail.

TABLE 5.13
"*FLUID-SPECIFIC*" TYPE IV HOLDOVER TIMES FOR 1999-2000
OCTAGON MAX-FLIGHT
Viscosity of Neat 100% Fluid Tested 2,920 cp

20°C, 0.3 RPM, Spindle LV1, 600 ml beaker, 500 ml fluid, 33 min 20 sec, grd.leg

OAT		Type IV Fluid Concentration	Approximate Holdover Times Anticipated Under Various Weather Conditions (hours:minutes)						
°C	°F	Neat-Fluid/Water (% by volume)	*FROST	FREEZING FOG	SNOW	***FREEZING DRIZZLE	LIGHT FRZ RAIN	RAIN ON COLD SOAKED WING	OTHER****
above 0°	above 32°	100/0	18:00	2:15-4:00	1:00-1:30	0:55-1:55	0:30-0:50	0:10-1:15	
		75/25	6:00	1:30-2:50	0:40-1:30	0:50-1:20	0:20-0:40	0:05-0:40	
		50/50	4:00	0:30-0:50	0:15-0:35	0:15-0:25	0:05-0:15	**CAUTION No holdover time guidelines exist**	
0 to -3	32 to 27	100/0	12:00	2:15-4:00	0:50-1:20	0:55-1:55	0:30-0:50		
		75/25	5:00	1:30-2:50	0:30-1:00	0:50-1:20	0:20-0:40		
		50/50	3:00	0:30-0:50	0:15-0:30	0:15-0:25	0:05-0:15		
below -3 to -14	below 27 to 7	100/0	12:00	0:45-1:55	0:25-0:50	**0:25-1:10	**0:15-0:40		
		75/25	5:00	0:30-1:10	0:20-0:40	**0:20-1:00	**0:15-0:30		
below -14 to -25	below 7 to -13	100/0	12:00	0:20-0:40	0:20-0:40				
below -25	below -13	100/0	SAE TYPE IV fluid may be used below -25°C (-13°F) provided the freezing point of the fluid is at least 7°C (13°F) below the OAT and the aerodynamic acceptance criteria are met. Consider use of SAE Type I when SAE Type IV fluid cannot be used.						

* During conditions that apply to aircraft protection for ACTIVE FROST.

** The lowest use temperature is limited to -10°C (14°F).

*** Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.

**** Heavy snow, snow pellets, snow grains, ice pellets, moderate and heavy freezing rain, and hail.

TABLE 5.14

"*FLUID-SPECIFIC*" TYPE IV HOLDOVER TIMES FOR 1999-2000

SPCA AD-480

Viscosity of Neat 100% Fluid Tested 21,200 cp

20°C, 0.3 RPM, Spindle SC4-34/13R, 10 ml fluid, 30 min

OAT		Type IV Fluid Concentration Neat-Fluid/Water (% by volume)	Approximate Holdover Times Anticipated Under Various Weather Conditions (hours:minutes)						
°C	°F		*FROST	FREEZING FOG	SNOW	***FREEZING DRIZZLE	LIGHT FRZ RAIN	RAIN ON COLD SOAKED WING	OTHER****
above 0°	above 32°	100/0	18:00	1:05-2:15	1:10-2:00	1:05-2:00	0:50-1:10	0:15-0:55	CAUTION No holdover time guidelines exist
		75/25	6:00	1:05-1:45	0:45-1:25	0:50-1:20	0:35-0:50	0:10-0:40	
		50/50	4:00	0:20-0:35	0:15-0:35	0:15-0:35	0:10-0:25		
0 to -3	32 to 27	100/0	12:00	1:05-2:15	1:05-1:50	1:05-2:00	0:50-1:10		
		75/25	5:00	1:05-1:45	0:45-1:25	0:50-1:20	0:35-0:50		
		50/50	3:00	0:20-0:35	0:10-0:30	0:15-0:35	0:10-0:25		
below -3 to -14	below 27 to 7	100/0	12:00	0:40-1:30	0:30-0:55	**0:25-1:20	**0:20-0:40		
		75/25	5:00	0:25-1:00	0:25-0:45	**0:30-1:15	**0:20-0:35		
below -14 to -25	below 7 to -13	100/0	12:00	0:20-0:40	0:25-0:40				
below -25	below -13	100/0	SAE TYPE IV fluid may be used below -25°C (-13°F) provided the freezing point of the fluid is at least 7°C (13°F) below the OAT and the aerodynamic acceptance criteria are met. Consider use of SAE Type I when SAE Type IV fluid cannot be used.						

* During conditions that apply to aircraft protection for ACTIVE FROST.

** The lowest use temperature is limited to -10°C (14°F).

*** Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.

**** Heavy snow, snow pellets, snow grains, ice pellets, moderate and heavy freezing rain, and hail.

TABLE 5.15

"*FLUID-SPECIFIC*" TYPE IV HOLDOVER TIMES FOR 1999-2000

UCAR ULTRA+

Viscosity of Neat 100% Fluid Tested 36,000 cp

0°C, 0.3 RPM, Spindle SC4-31/13R, 10 ml fluid, 10 min

OAT		Type IV Fluid Concentration Neat-Fluid/Water (% by volume)	Approximate Holdover Times Anticipated Under Various Weather Conditions (hours:minutes)						
°C	°F		*FROST	FREEZING FOG	SNOW	***FREEZING DRIZZLE	LIGHT FRZ RAIN	RAIN ON COLD SOAKED WING	OTHER****
above 0°	above 32°	100/0	18:00	1:35-3:35	0:40-1:25	0:45-1:35	0:25-0:40	0:10-1:20	CAUTION No holdover time guidelines exist
		75/25							
		50/50							
0 to -3	32 to 27	100/0	12:00	1:35-3:35	0:35-1:15	0:45-1:35	0:25-0:40		
		75/25							
		50/50							
below -3 to -14	below 27 to 7	100/0	12:00	1:25-3:00	0:25-0:55	**0:45-1:25	**0:30-0:45		
		75/25							
below -14 to -25	below 7 to -13	100/0	12:00	0:40-2:10	0:20-0:45				
below -25	below -13	100/0	SAE TYPE IV fluid may be used below -25°C (-13°F) provided the freezing point of the fluid is at least 7°C (13°F) below the OAT and the aerodynamic acceptance criteria are met. Consider use of SAE Type I when SAE Type IV fluid cannot be used.						

* During conditions that apply to aircraft protection for ACTIVE FROST.

** The lowest use temperature is limited to -10°C (14°F).

*** Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.

**** Heavy snow, snow pellets, snow grains, ice pellets, moderate and heavy freezing rain, and hail.

6. SUPPLEMENTARY TESTS

APS conducted supplementary tests in addition to the ones specifically intended to determine the holdover times for qualified fluids. The supplementary tests and their corresponding results are presented in this section. These tests are listed below in order of presentation:

- Data related to natural freezing precipitation conditions other than snow are given in Subsection 6.1;
- The evaluation of the holdover time and compatibility performance of Inland recycled fluids, in Subsection 6.2;
- The influence of fluid viscosity on holdover time, in Subsection 6.3;
- The evaluation of the holdover time performance of a reference fluid, in Subsection 6.4;
- The evaluation of fog deposition rates in natural conditions, in Subsection 6.5;
- The evaluation of frost deposition rates in natural conditions, in Subsection 6.6;
- The evaluation of ice-phobic (IP) materials, in Subsection 6.7; and
- The compilation of an aircraft icing-related accident/incident database, in Subsection 6.8.

6.1 Natural Freezing Precipitation Tests Excluding Snow

Holdover time tests conducted in natural freezing precipitation events other than snow were carried out at the APS Dorval airport test site during the 1998-99 winter season. A breakdown of the 10 tests conducted, by fluid type, is summarized below. The 10 tests were conducted during ice pellet conditions.

Fluid Type	# of Tests	Condition
Type IV 50/50	4	Ice Pellets
Type II 50/50	2	Ice Pellets
Type I (Standard)	4	Ice Pellets
TOTAL TESTS	10	

Comparisons between the fluid failure times recorded in these ice pellet conditions and the results of tests conducted in natural snow events are shown in Figures 6.1 to 6.3.

No current criteria exist for the determination of fluid failures in ice pellet conditions, due to ambiguities related to calling failures in this condition. Failures were determined by the plate observer based solely on personal opinion. It should also be noted that no holdover time guidelines exist for this category of precipitation, and that operations in ice pellet conditions are not recommended.

In general, the holdover times of the fluids tested in ice pellet conditions were similar to those resulting from tests conducted in natural snow.

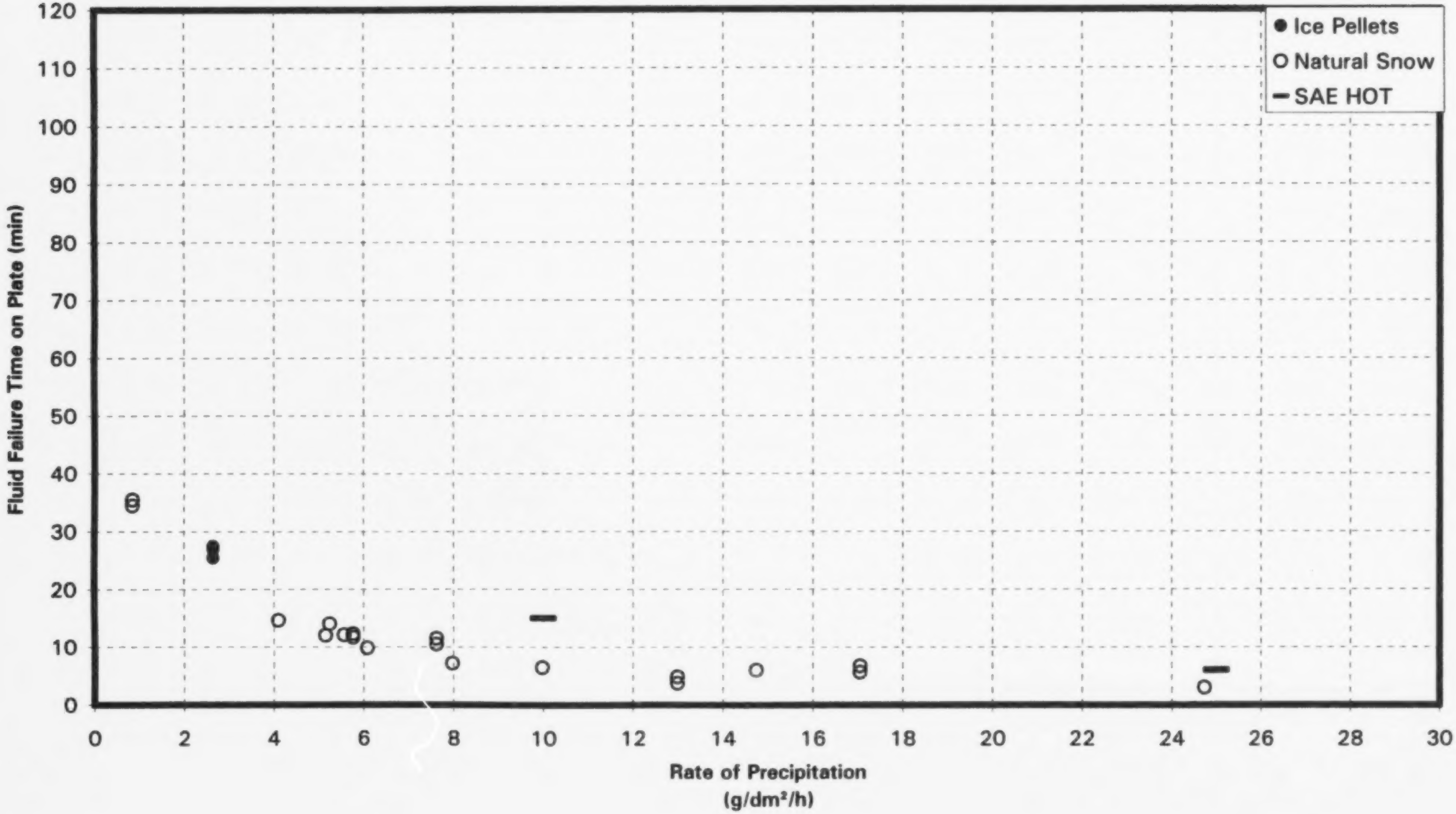
FIGURE 6.1

EFFECT OF RATE OF PRECIPITATION ON ENDURANCE TIME

UCAR XL54 - TYPE I

NATURAL SNOW AND ICE PELLETS CONDITIONS

1998-99



cm1514/report/hot_subs/Figure 6.1-3
At: XL54

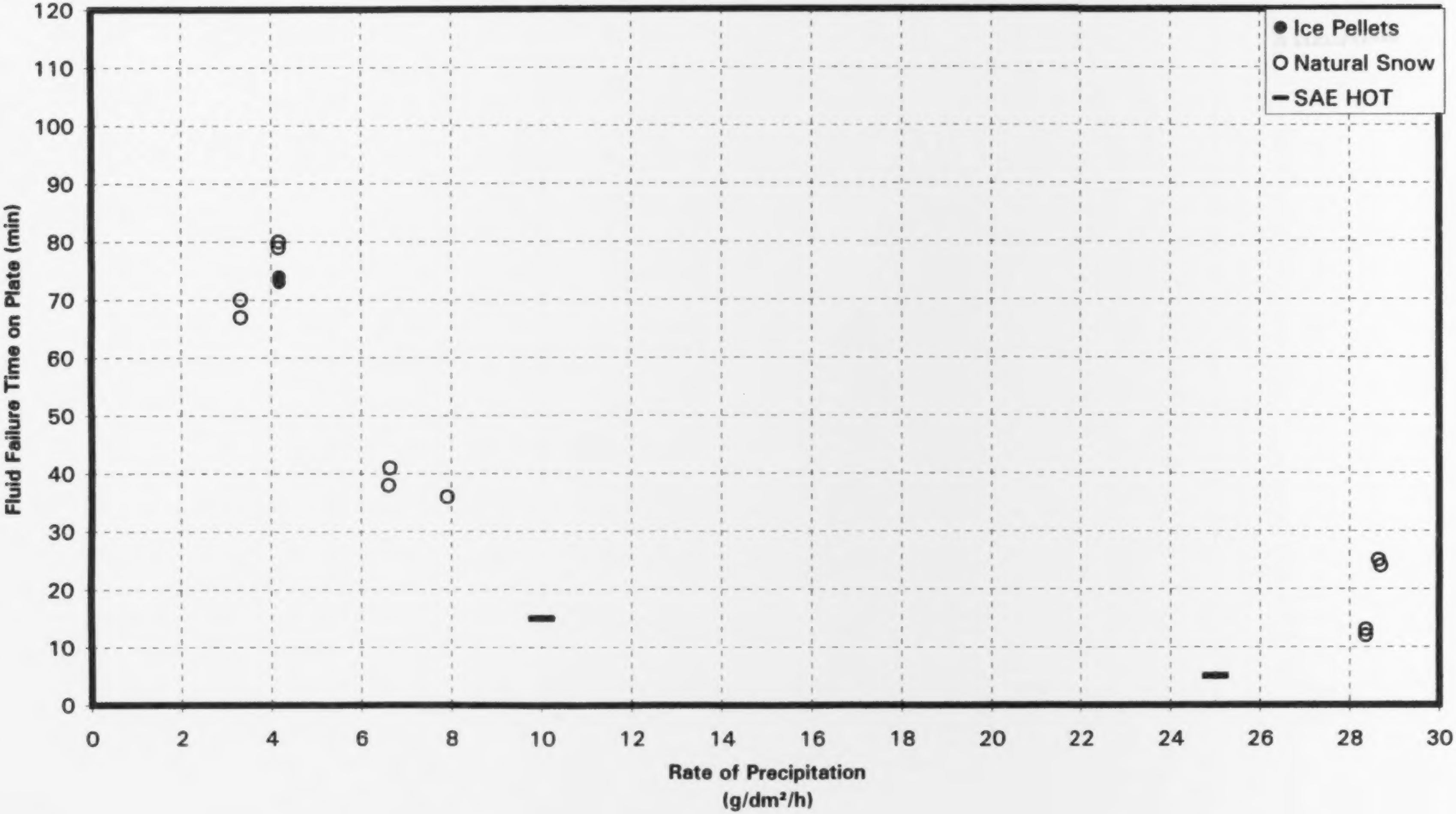
FIGURE 6.2

EFFECT OF RATE OF PRECIPITATION ON ENDURANCE TIME

KILFROST ABC-II PLUS 50/50 (0 TO -3°C)

NATURAL SNOW AND ICE PELLETS CONDITIONS

1998-99



cm1514/report/hot_subs/Figure 6.1-3
At: Kilfrost

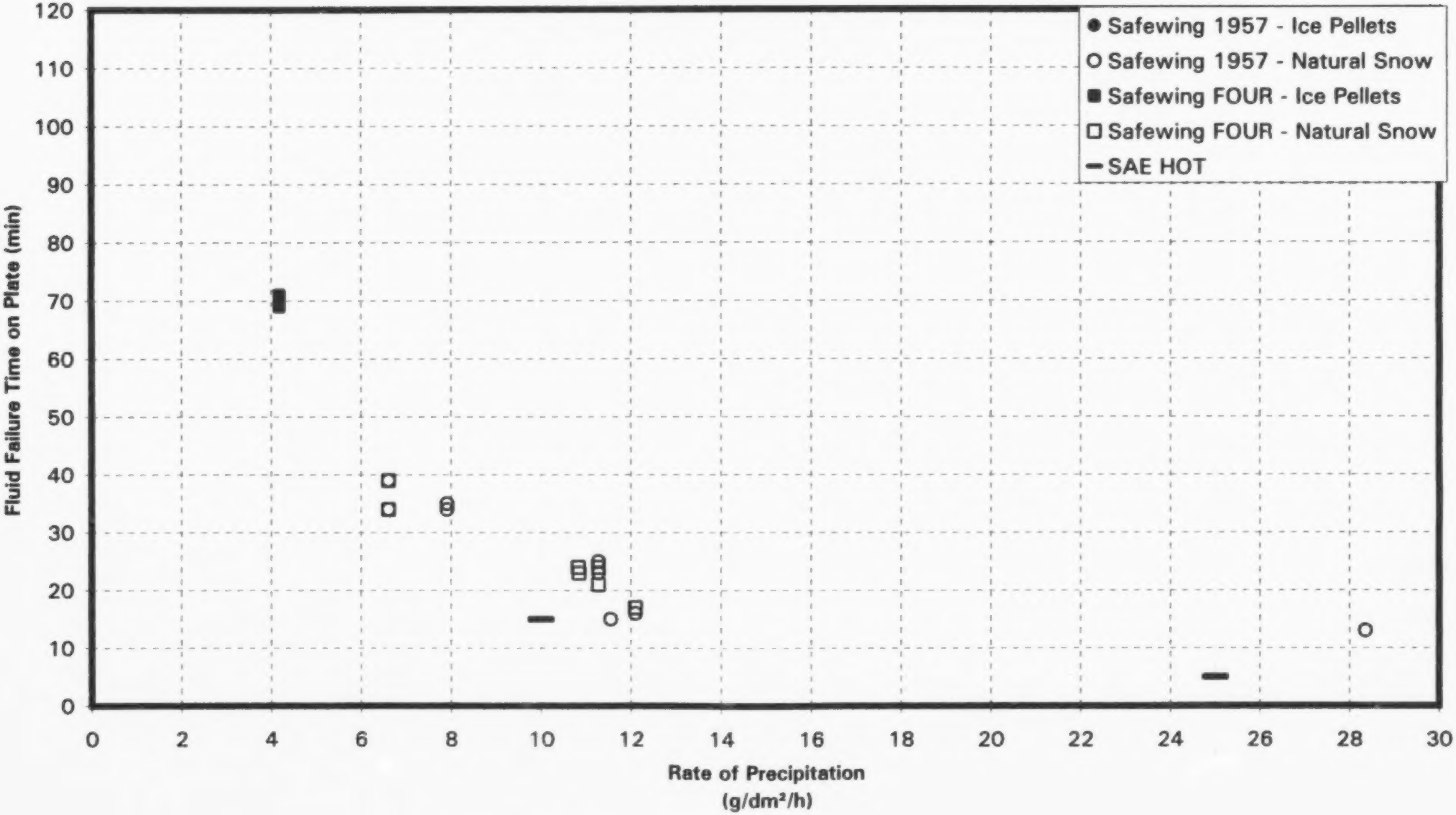
FIGURE 6.3

EFFECT OF RATE OF PRECIPITATION ON ENDURANCE TIME

CLARIANT TYPE IV 50/50 (0 TO -3°C)

NATURAL SNOW AND ICE PELLETS CONDITIONS

1998-99



cm1514/report/hot_subs/Figure 6.1-3
At: Type IV

6.2 Evaluation of Recycled Fluids

Under contract to TDC, APS Aviation proceeded to evaluate the holdover time performance and fluid compatibility performance of two recycled fluids (one ethylene glycol-based and one propylene glycol-based). Both fluids were supplied in ready-to-use concentration by Inland Technologies Inc.

The fluids are currently being marketed as Type I deicing fluids. The Inland recycled propylene glycol-based fluid will be referred to as Inland Duragly-P, while the Inland recycled ethylene glycol-based fluid will be referred to as Inland Duragly-E. Both fluids satisfactorily passed all fluid certification tests during the past year.

A series of preliminary holdover time and compatibility tests were performed by APS in 1996-97 using one batch of recycled ethylene fluid provided by Inland in Dorval. The results of these tests appear in Transport Canada report TP 13131E (8). Compatibility and holdover time testing using both recycled propylene and recycled ethylene fluids from Inland Technologies was also conducted in 1997-98. The results of these tests appear in Transport Canada report TP 13318E (1).

6.2.1 Holdover Time

Over the past three test seasons, APS has conducted holdover time tests with Inland fluids in natural snow, light freezing rain, freezing drizzle, freezing fog and rain on a cold-soaked wing conditions.

The procedures used in the outdoor tests on the recycled fluids in natural snow appear in Appendix J.

In total, 59 holdover time tests were conducted in 1998-99 with Inland fluids in natural snow, including:

- 18 tests with Inland Duragly-P fluid; and
- 41 tests with Inland Duragly-E fluid.

The majority of holdover time tests using recycled fluids in natural snow conditions were conducted alongside plates of commercial Type I fluids for holdover time comparison. The results of these snow tests, including the Type I results, are plotted in the form of fluid failure time versus rate of precipitation and are displayed in Figures 6.4 and 6.5.

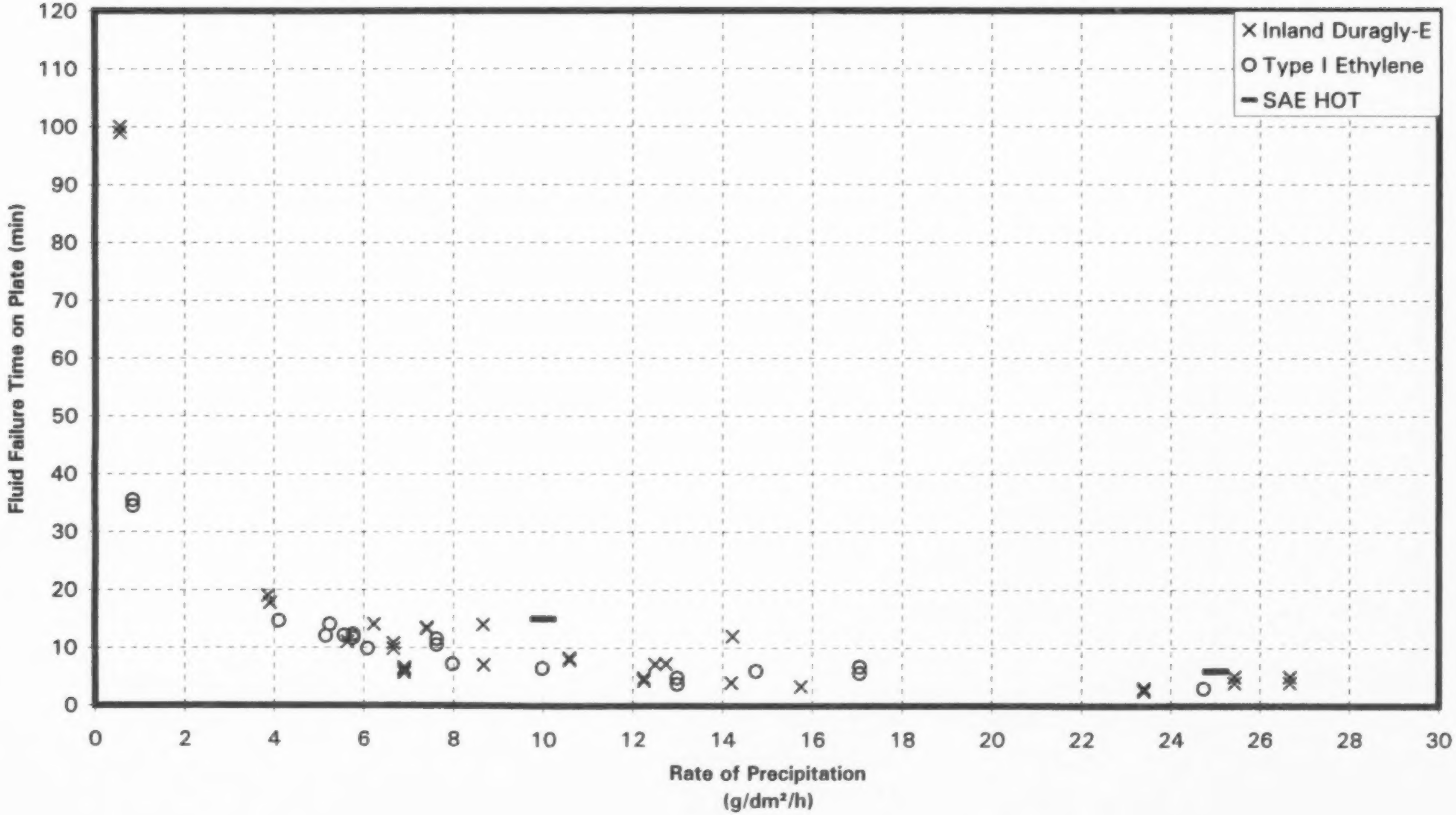
FIGURE 6.4

EFFECT OF RATE OF PRECIPITATION ON ENDURANCE TIME

INLAND DURAGLY-E

NATURAL SNOW CONDITIONS

1998-99



cm1514/report/hot_subs/Figures 6.4-6.5
At: Ethylene

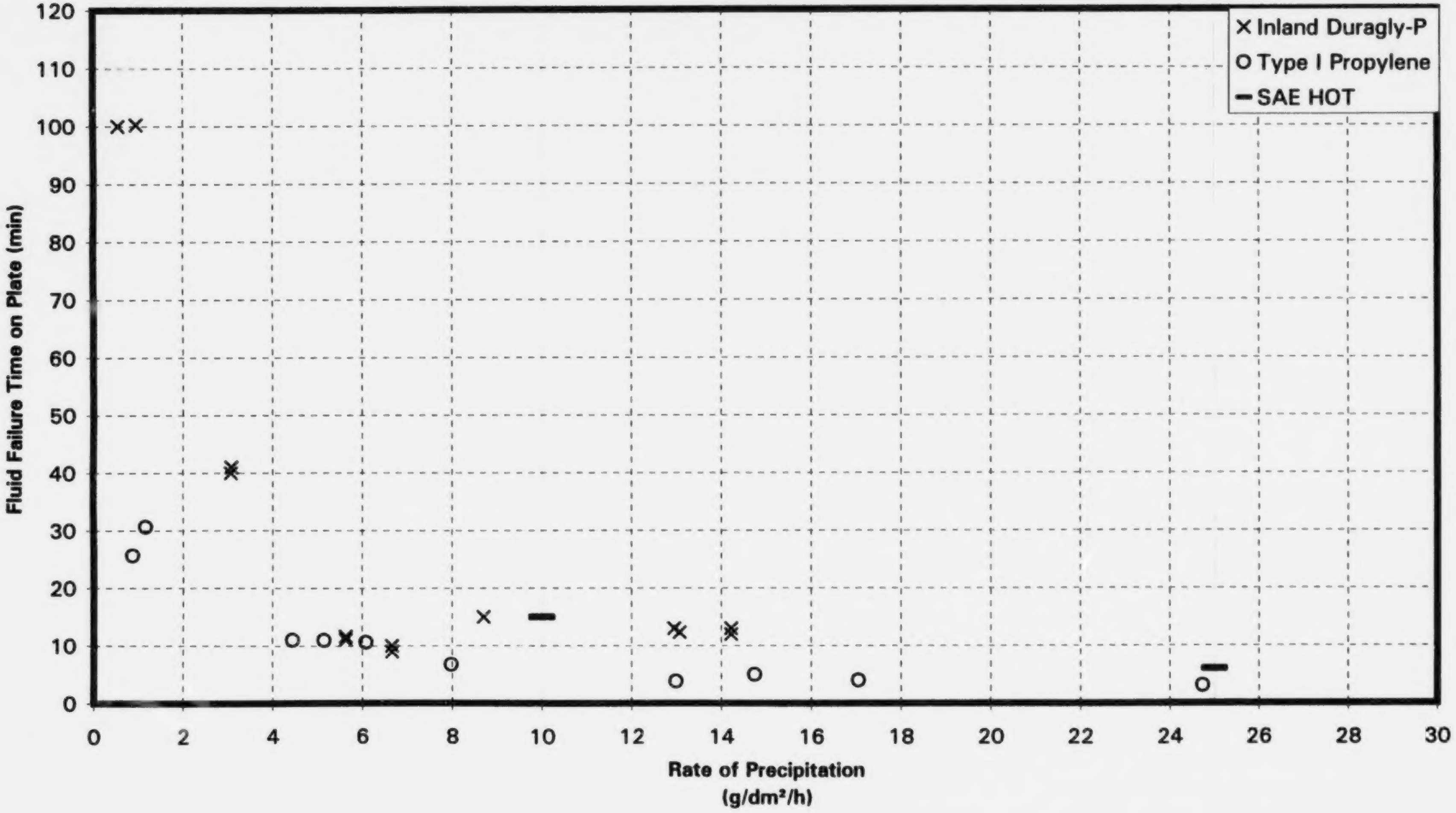
FIGURE 6.5

EFFECT OF RATE OF PRECIPITATION ON ENDURANCE TIME

INLAND DURAGLY-P

NATURAL SNOW CONDITIONS

1998-99



cm1514/report/hot_subs/Figures 6.4-6.5
At: Propylene

In general, the holdover time results of Inland fluids in natural snow were similar to those of the commercial Type I fluids tested. In several cases, the Inland Duragly-P actually outperformed the certified propylene glycol-based Type I fluid.

Holdover time tests on Inland recycled fluids in freezing drizzle and light freezing rain were performed at NRC's CEF in Ottawa. The procedures used in the indoor tests in simulated conditions appear in Appendix C.

Ten Inland recycled ethylene fluid tests were performed in 1996-97. The results of these tests were compared to ten plates of standard Type I fluid. The holdover times of the Inland fluid plates resembled those of the Type I fluid plates (see Transport Canada report, TP 13131E (8)). Twenty holdover time tests were performed in freezing drizzle and light freezing rain with Inland recycled fluids in 1997-98. These tests involved ten with recycled ethylene and ten with recycled propylene. The holdover times from the Inland fluid tests were, once again, similar to those obtained from the Type I fluid tests (1).

In 1998-99, 31 tests were conducted with the recycled fluids in light freezing rain and freezing drizzle, alongside tests with both ethylene and propylene Type I fluids. All fluids were tested in their standard concentrations. The holdover time results of the recycled fluids were similar to those obtained from the Type I fluids (see Figure 6.6).

The results of tests conducted in the conditions of freezing fog and in rain on a cold-soaked wing are shown in Figures 6.7 and 6.8. Once again, the results obtained with the Inland fluids in ready-to-use concentration closely compare to those of the standard Type I fluids.

6.2.2 Compatibility Tests

Preliminary tests, aimed at determining the compatibility of Inland recycled ethylene fluid with commercial ethylene Type I and Type IV fluids were conducted in 1996-97. The results showed that the recycled fluid was compatible with all the Type I and Type IV fluids tested. The complete result summary of these tests appears in last year's holdover time report (8).

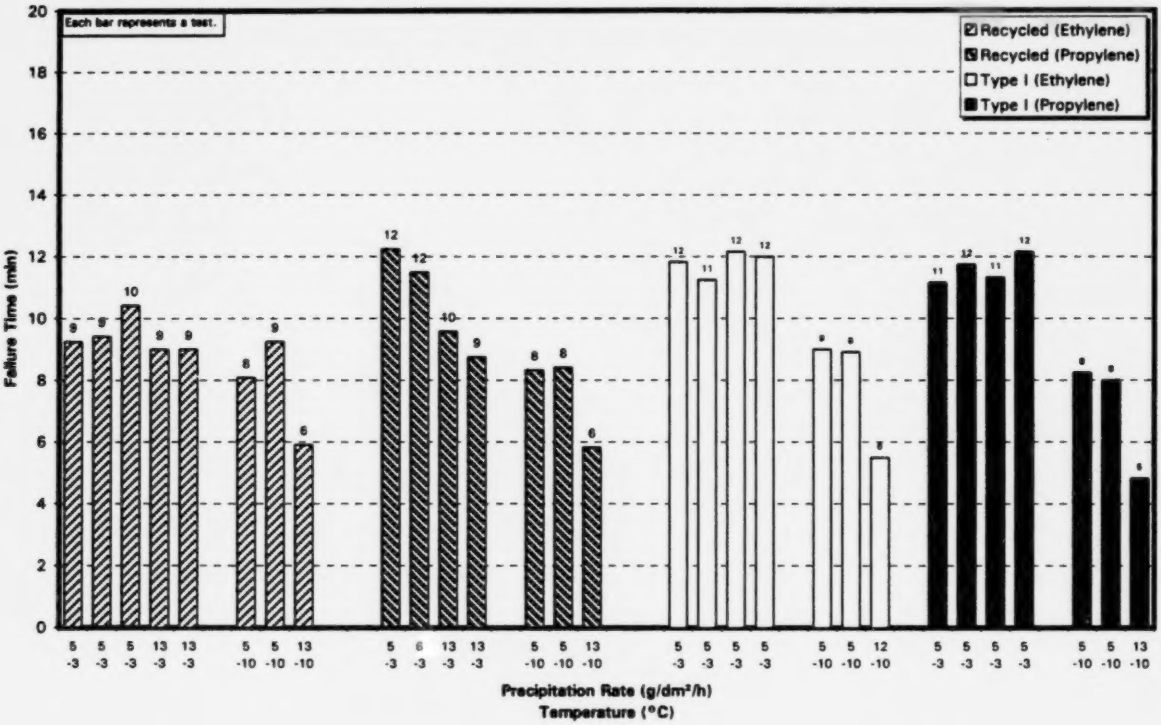
A more elaborate series of tests, involving various combinations of ethylene and propylene recycled fluids, as well as commercial ethylene and propylene Type I and Type IV fluids, were performed during 1997-98 in light freezing rain and freezing drizzle at NRC's CEF in Ottawa (see report TP 13318E (1)).

FIGURE 6.6

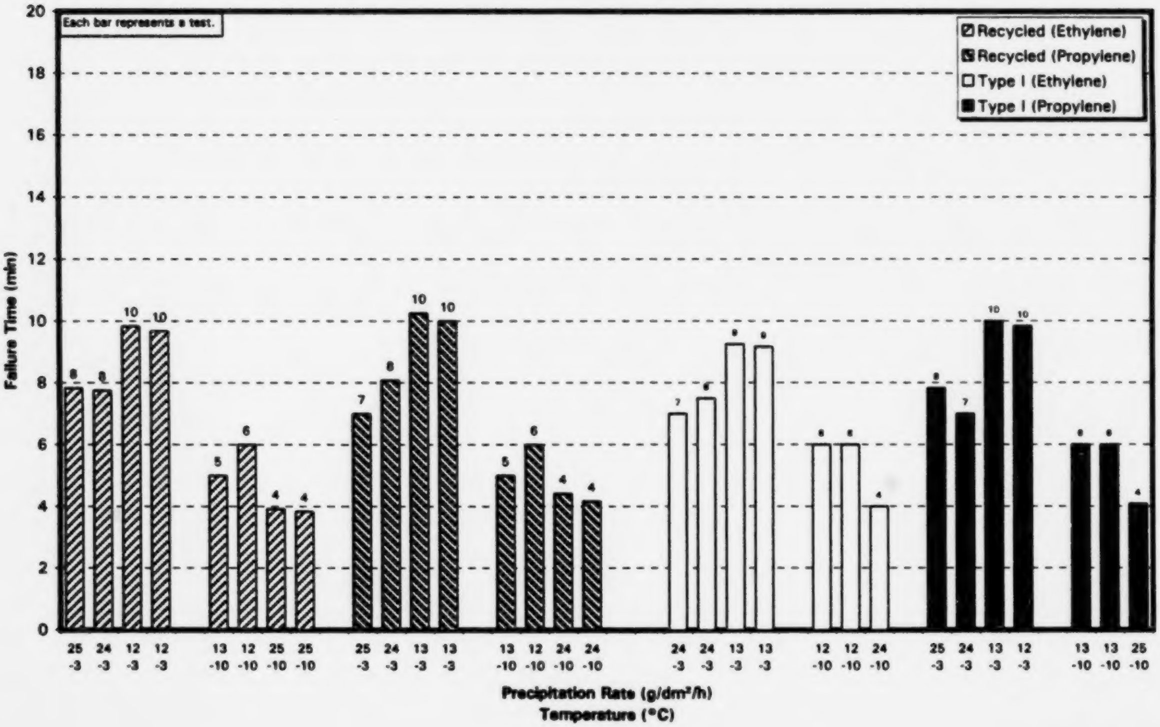
EFFECT OF TEMPERATURE AND RATE OF PRECIPITATION ON FAILURE TIME

COMPARISON OF TYPE I AND RECYCLED FLUIDS

Freezing Drizzle



Light Freezing Rain



cm1514/report/hot_sub/Figure 6.6
At: ZR & ZD

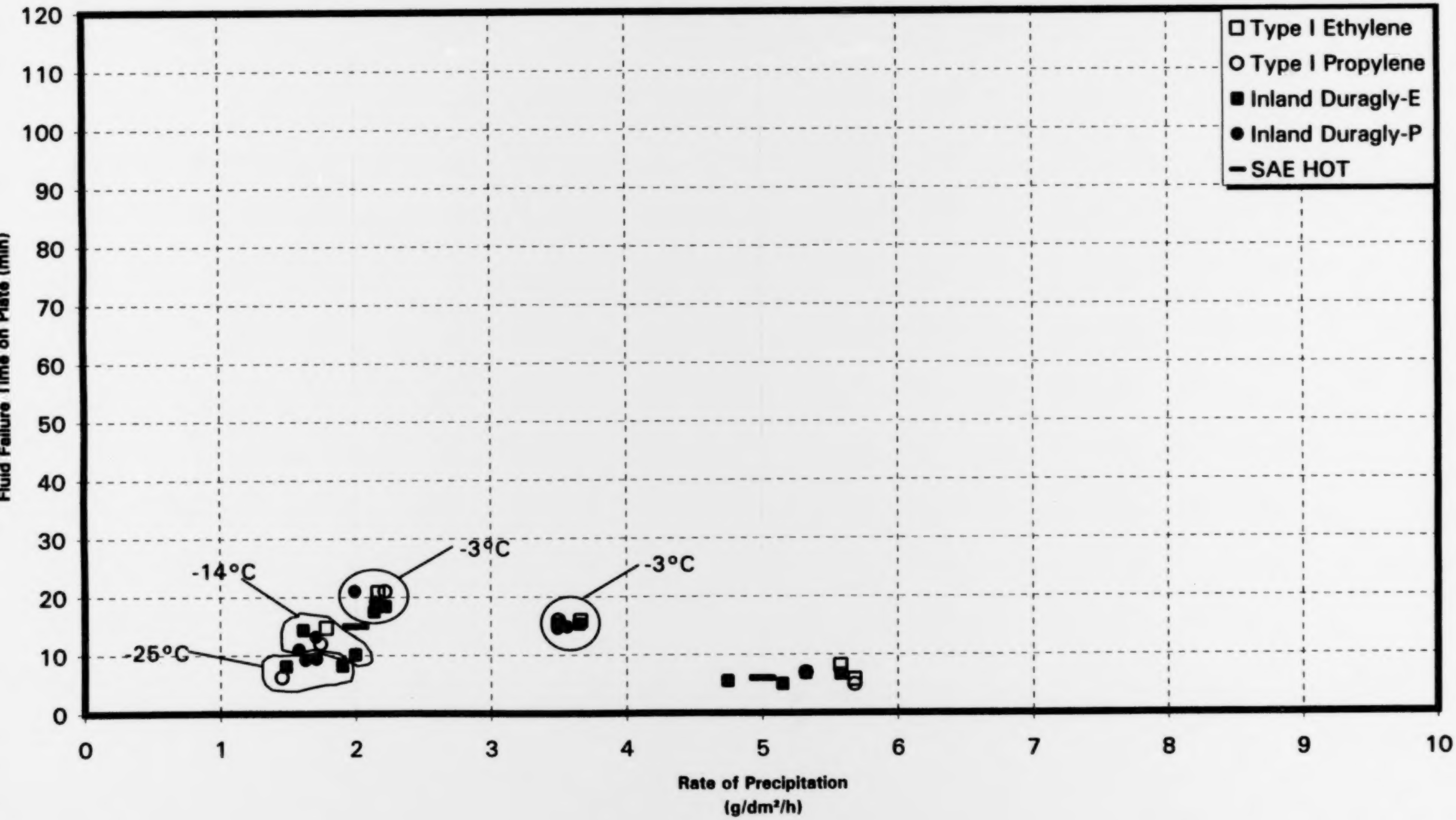
FIGURE 6.7

EFFECT OF RATE OF PRECIPITATION ON ENDURANCE TIME

COMPARISON OF TYPE I (STANDARD) AND RECYCLED FLUIDS

SIMULATED FREEZING FOG

1998-99



cm1514/report/hot_subs/Figure 6.7-6.8
At: Fog

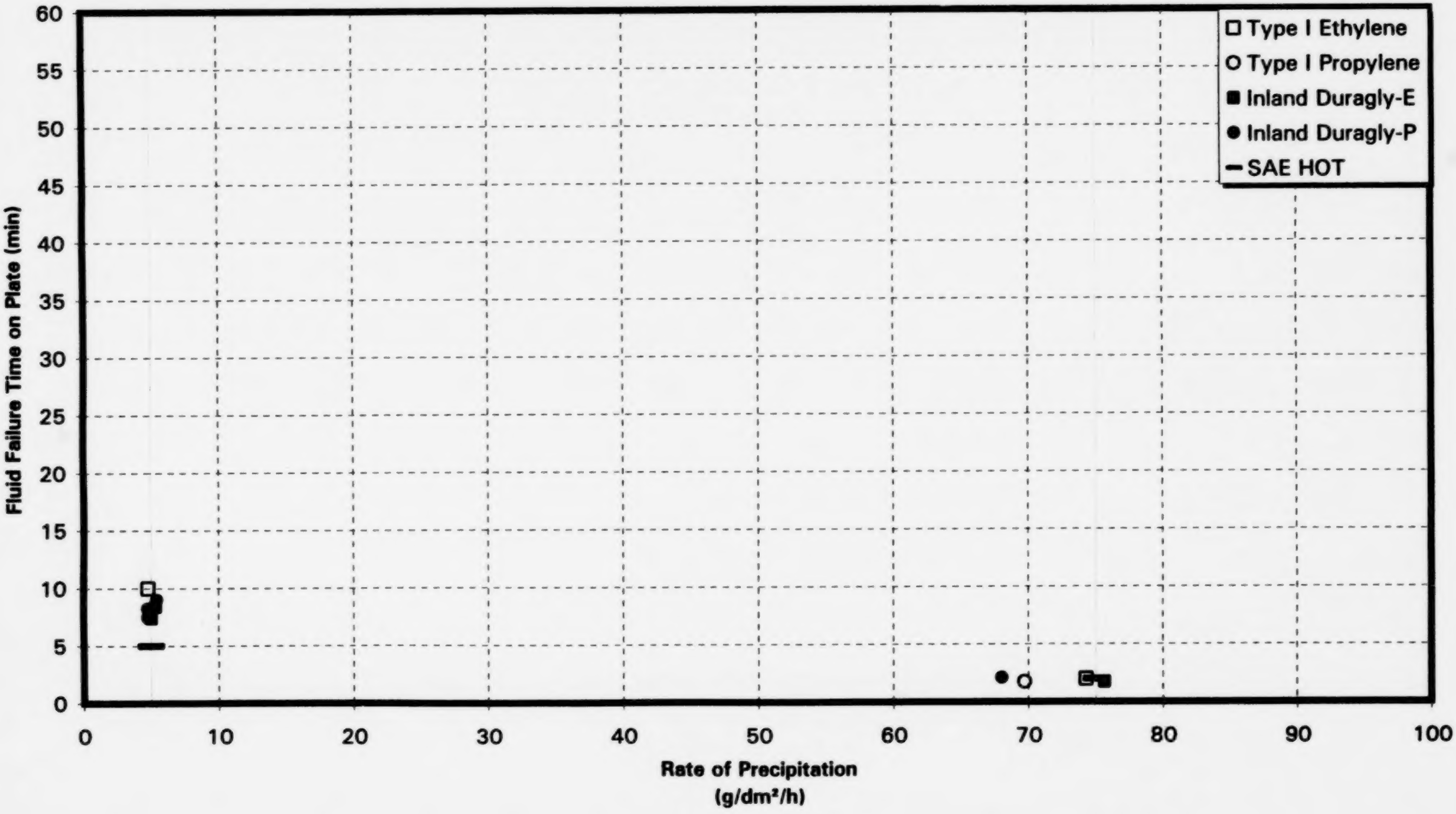
FIGURE 6.8

EFFECT OF RATE OF PRECIPITATION ON ENDURANCE TIME

COMPARISON OF TYPE I (STANDARD) AND RECYCLED FLUIDS

SIMULATED RAIN ON COLD-SOAKED BOXES

1998-99



cm1514/report/hot_subs/Figure 6.7-6.8
At: CS

In 1998-99 compatibility tests were once again performed. In general, the test procedure consisted of running standard holdover time tests with selected Type I and Type IV fluids, and then re-testing the same fluids in two-step applications, consisting of:

- Type IV fluids over Type I fluids;
- Type IV fluids over recycled fluids; and
- Type I fluids over recycled fluids.

Tests were conducted to determine the effect of the undercoat on the holdover time of the second-step fluid.

Compatibility tests were divided in two groups:

- Compatibility of recycled fluids with commercial Type I fluids; and
- Compatibility of recycled fluids with commercial Type IV fluids.

6.2.2.1 Compatibility Tests with Type I Fluids

The results of tests conducted to determine the compatibility performance of recycled Type I fluids and commercial Type I fluids in natural snow are shown in Figure 6.9. Each bar represents the holdover time result of the fluid(s) tested. The rate of precipitation and the test temperature are displayed below each bar. The holdover time performances of the commercial Type I fluids were similar to that of Inland Duragly-E. The holdover times of the Type I fluids were generally higher when Inland Duragly-E was used as an undercoat. This tends to suggest good compatibility between the fluids.

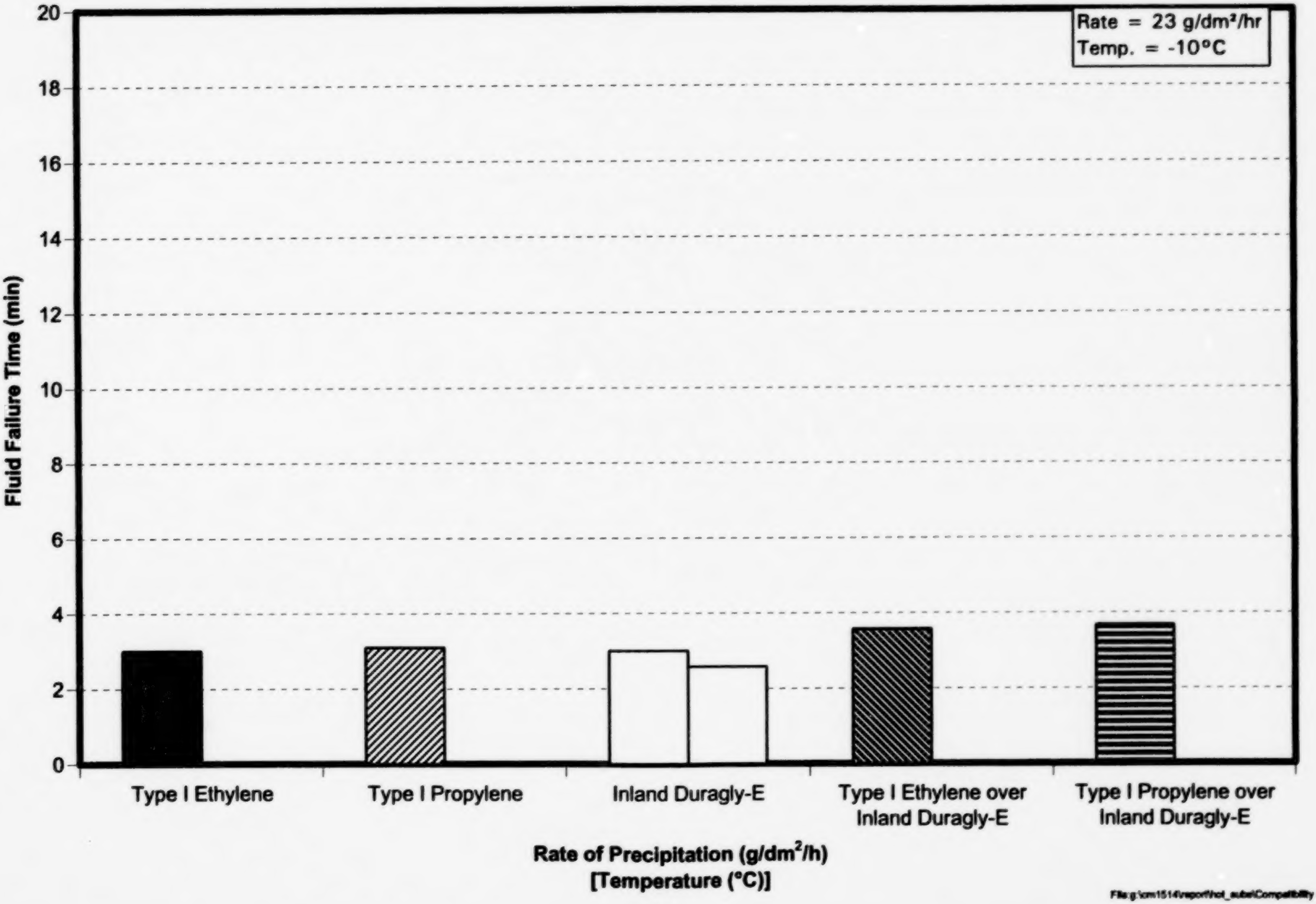
Additional compatibility tests with commercial Type I fluids were conducted in light freezing rain and freezing drizzle. The results of these tests are displayed in Figures 6.10 and 6.11. In general, the results show that recycled fluid undercoat does not affect the holdover time of the Type I fluid.

FIGURE 6.9

COMPATIBILITY OF RECYCLED FLUIDS WITH TYPE I

NATURAL SNOW

1998-99

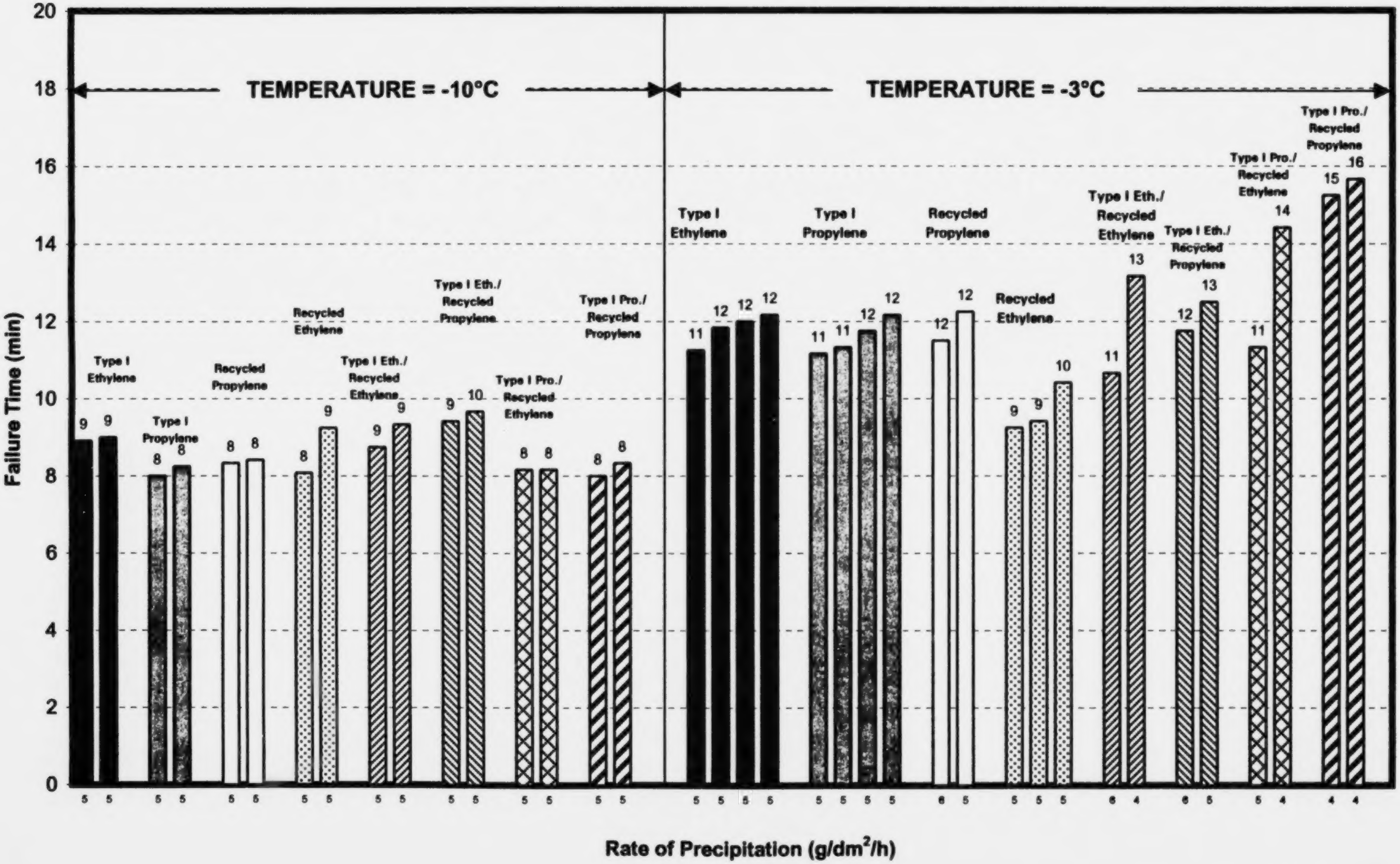


File:g:\cm1514\report\hot_subs\Compatibility - Snow2
At: 6-9

FIGURE 6.10

COMPATIBILITY OF RECYCLED FLUIDS WITH TYPE I

SIMULATED FREEZING DRIZZLE

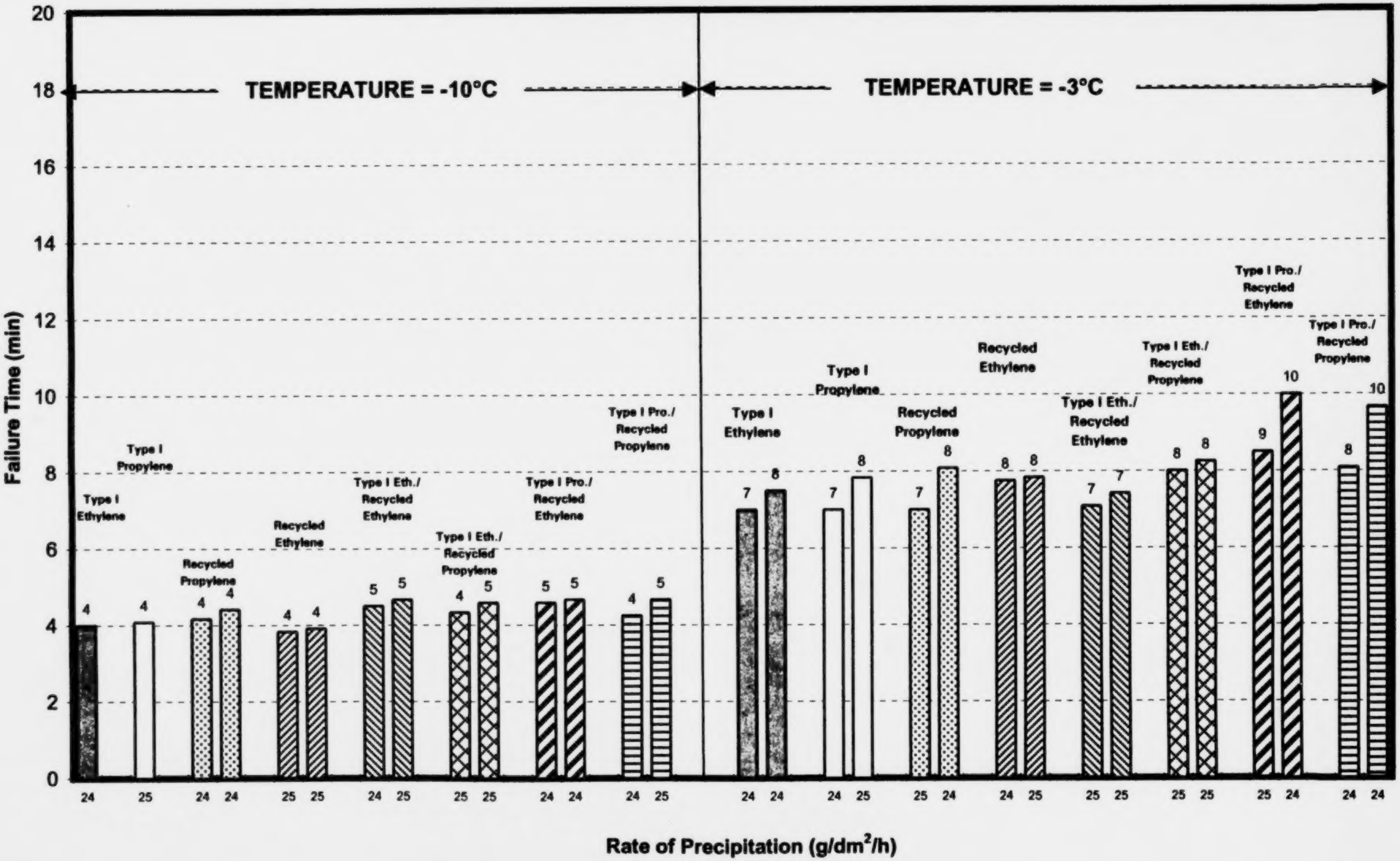


File:g:\cm1514\report\hot_subs\Figures 6.10-11
At: ZD

FIGURE 6.11

COMPATIBILITY OF RECYCLED FLUIDS WITH TYPE I

SIMULATED LIGHT FREEZING RAIN



File:g:\cm1514\report\hot_subs\Figures 6.10-11
At: ZR

6.2.2.2 Compatibility Tests with Type IV Fluid

The results of recycled fluid compatibility tests with Type IV fluids in natural snow are displayed in Figures 6.12 and 6.13.

Previous compatibility tests suggested that the holdover times of Type IV fluids applied in two-step applications are lower than those of Type IV fluids applied without an undercoat (1).

Figure 6.12 compares the holdover time performances of Type IV fluids in single-step applications with those of commercial Type IV fluids in two-step applications with commercial Type I and Inland Duragly-E. The holdover times of the Type IV fluids decreased on average by 11 to 27 percent when applied in a two-step operation. The largest reduction in holdover time was observed with Type IV propylene fluids over the Inland Duragly-E fluid.

The continuation of Figure 6.12 compares the holdover time results of ethylene and propylene Type IV fluids with four undercoats. No consistent trend was observed.

Compatibility tests using an ethylene Type IV fluid in freezing drizzle are shown in Figure 6.13. In general, the holdover times of the Type IV fluid were reduced by about 10 to 25 percent in tests where a Type I or recycled fluid was applied prior to the Type IV. At -3°C, the largest difference in holdover time (25 percent reduction in Type IV holdover time, on average) exists when the ethylene recycled fluid was used under the ethylene Type IV. At -10°C, the largest difference in holdover time (17 percent reduction in Type IV holdover time, on average) exists when the propylene recycled fluid was again used under the ethylene Type IV.

Figure 6.14 shows the results of compatibility tests using an ethylene Type IV fluid in light freezing rain. In general, the holdover times of the Type IV fluid were reduced by roughly 15 percent when an undercoat was applied. No individual undercoat had significantly worse effects on the holdover time performance of the Type IV fluid.

Figure 6.15 displays the results of compatibility tests using a propylene Type IV fluid in freezing drizzle. An overall reduction of up to 13 percent in the Type IV holdover time is evident when an undercoat was applied. In this case, the largest difference in holdover time was noted when recycled ethylene was used as an undercoat.

Figure 6.16 shows the results of compatibility tests using a propylene Type IV fluid in light freezing rain conditions. In general, the holdover times of the Type IV fluid were reduced slightly when an undercoat was applied. No individual undercoat had significantly worse effects on the holdover time performance of the Type IV fluid.

FIGURE 6.12

COMPATIBILITY OF RECYCLED FLUIDS WITH TYPE IV

NATURAL SNOW

1998-99

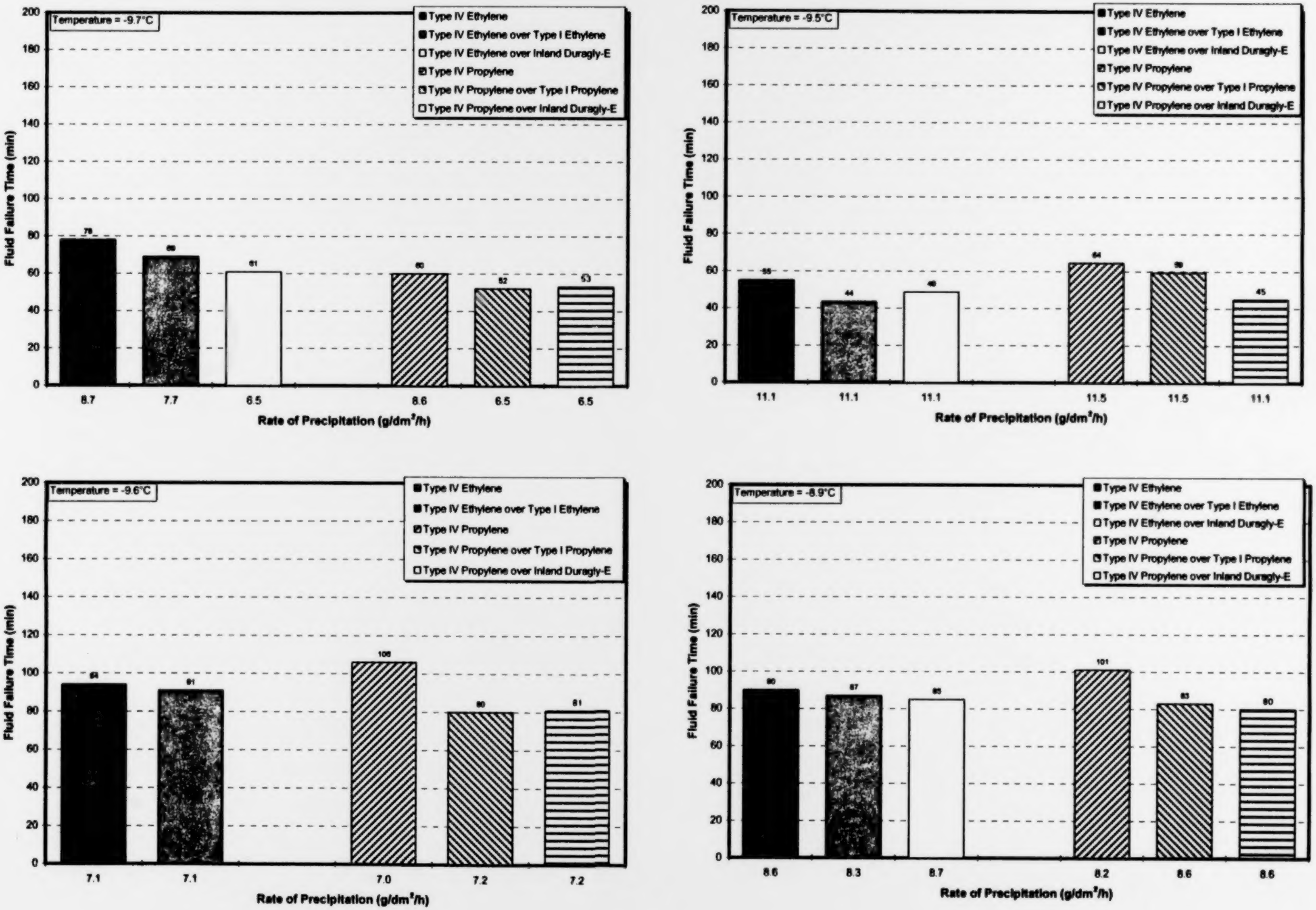


FIGURE 6.12

COMPATIBILITY OF RECYCLED FLUIDS WITH TYPE IV (cont.)

NATURAL SNOW

1998-99

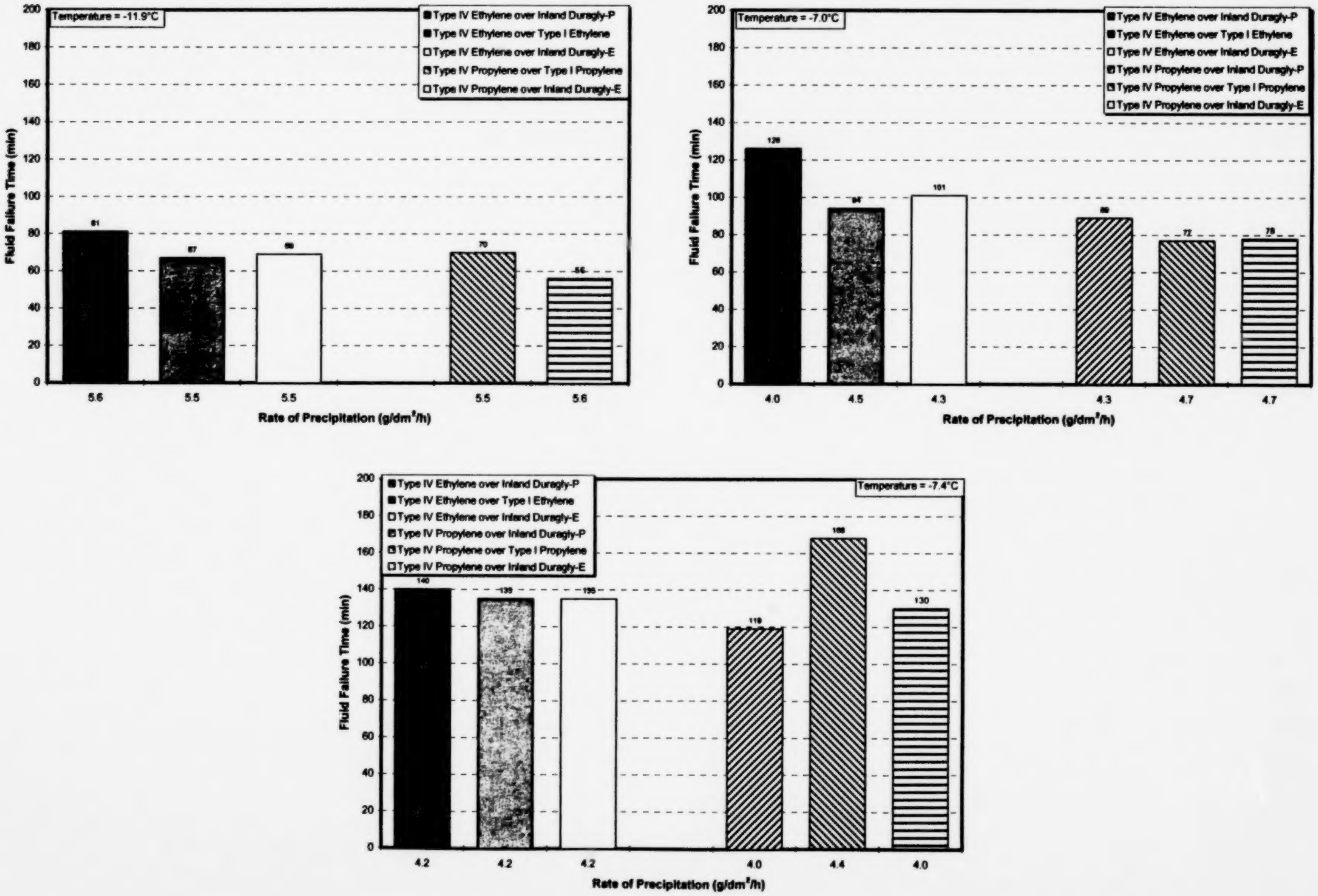


FIGURE 6.13

COMPATIBILITY OF RECYCLED FLUIDS WITH ETHYLENE TYPE IV

SIMULATED FREEZING DRIZZLE

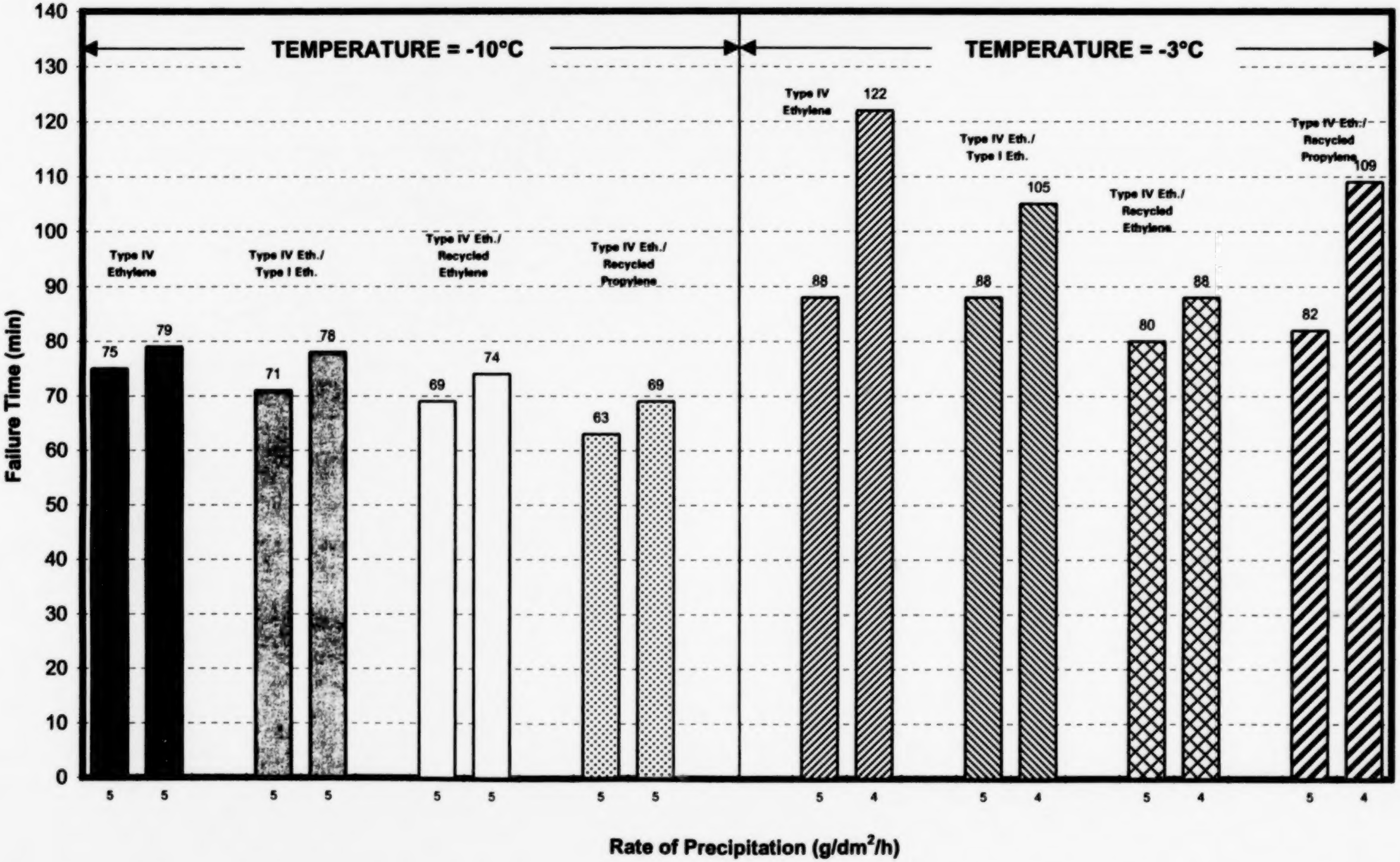
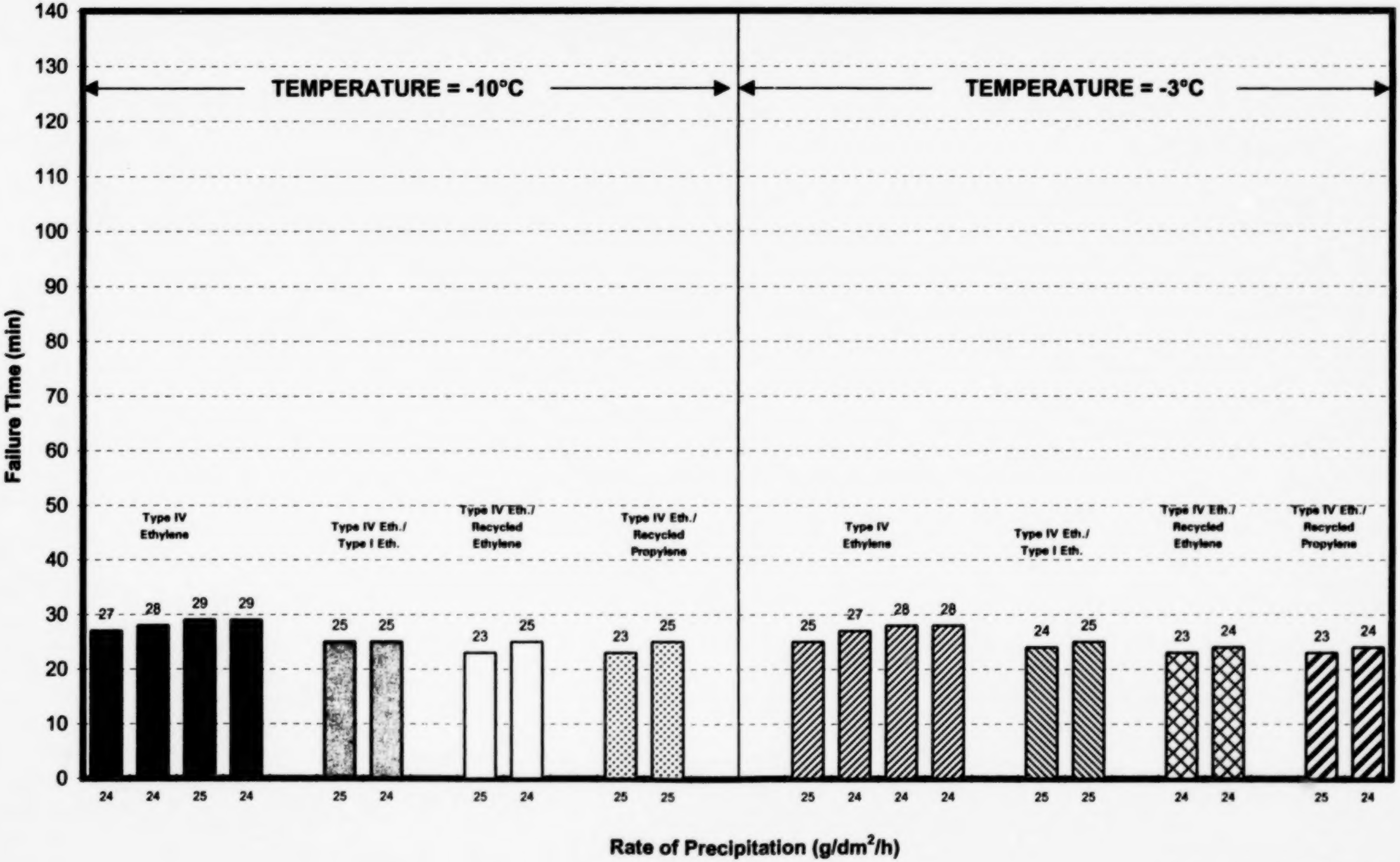


FIGURE 6.14

COMPATIBILITY OF RECYCLED FLUIDS WITH ETHYLENE TYPE IV

SIMULATED LIGHT FREEZING RAIN

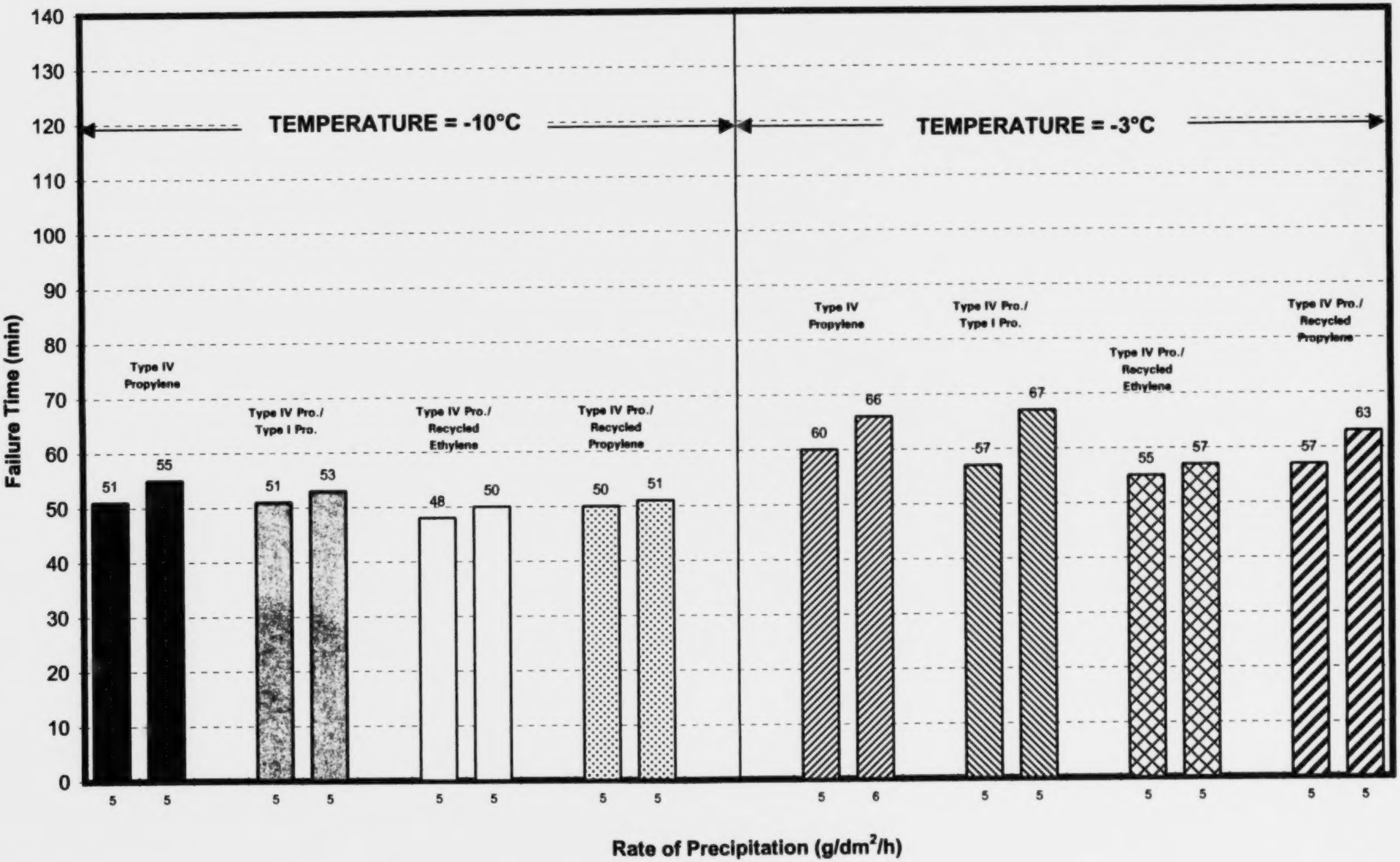


File:g:\cm1514\report\hot_subs\Figures 6.13-18
At: ZR - Eth

FIGURE 6.15

COMPATIBILITY OF RECYCLED FLUIDS WITH PROPYLENE TYPE IV

SIMULATED FREEZING DRIZZLE

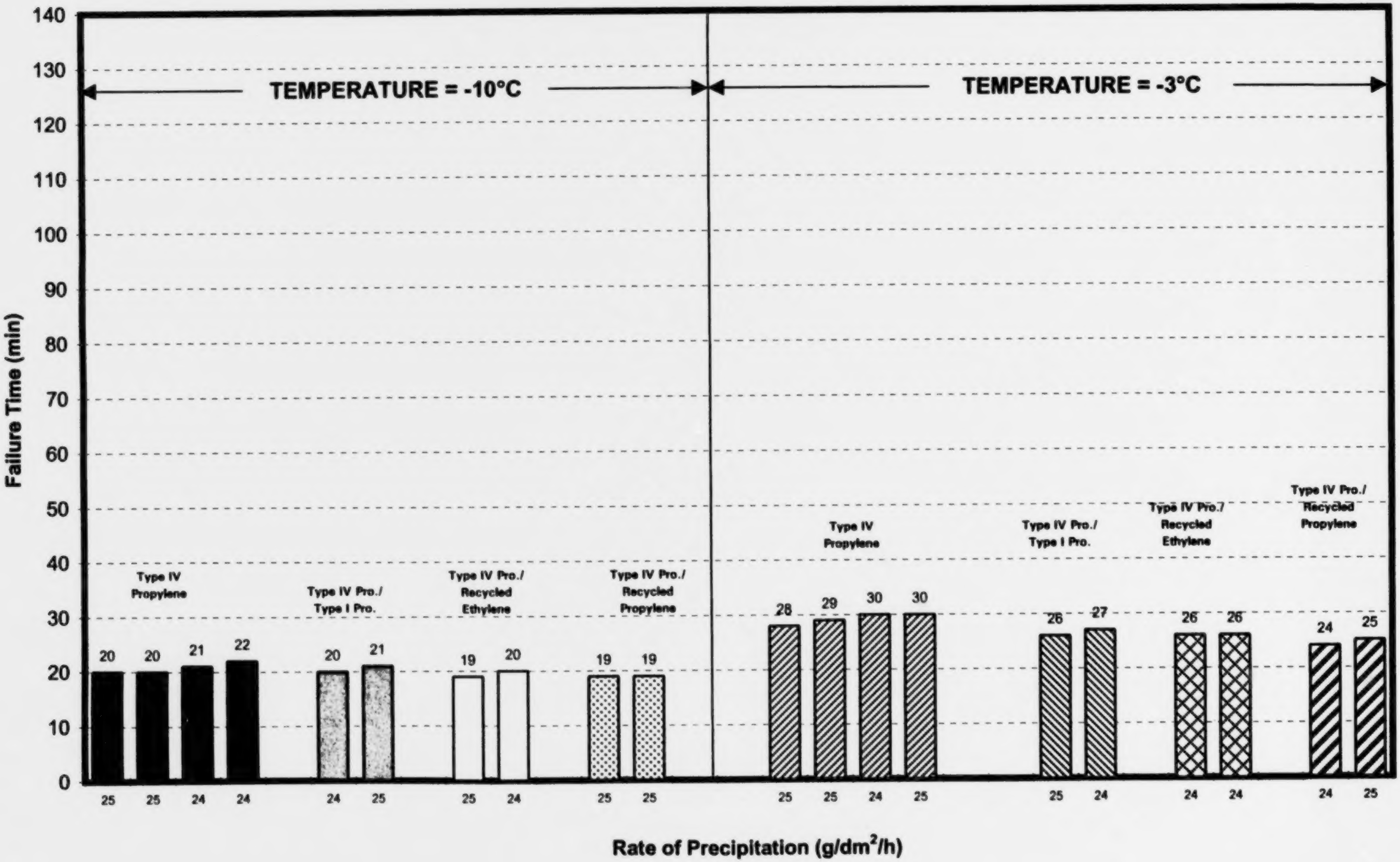


File:g:\cm1514\report\hot_sube\Figures 6.13-16
At: ZD - Prop

FIGURE 6.16

COMPATIBILITY OF RECYCLED FLUIDS WITH PROPYLENE TYPE IV

SIMULATED LIGHT FREEZING RAIN



cm1514\report\hot_subs\Figures 6.13-16
At: ZR - Prop

6.3 Influence of Fluid Viscosity on Holdover Time

A preliminary evaluation of the effect of fluid viscosity on holdover time was conducted in 1997-98 (1). These tests demonstrated that fluid viscosity might significantly influence fluid holdover times.

In 1998-99, APS requested that fluid manufacturers deliver unsheared fluid samples along with the sheared fluid required for holdover time testing. The holdover times of the sheared (low viscosity) and unsheared (high viscosity) fluid samples would be compared in simulated precipitation conditions in order to study the effect of fluid viscosity on holdover time.

The results of tests conducted to determine the influence of fluid viscosity on holdover time are shown in Figures 6.17 to 6.21. Tests were performed at the high rate of precipitation in light freezing rain and at the low rate of precipitation in freezing drizzle, at both -10°C and -3°C.

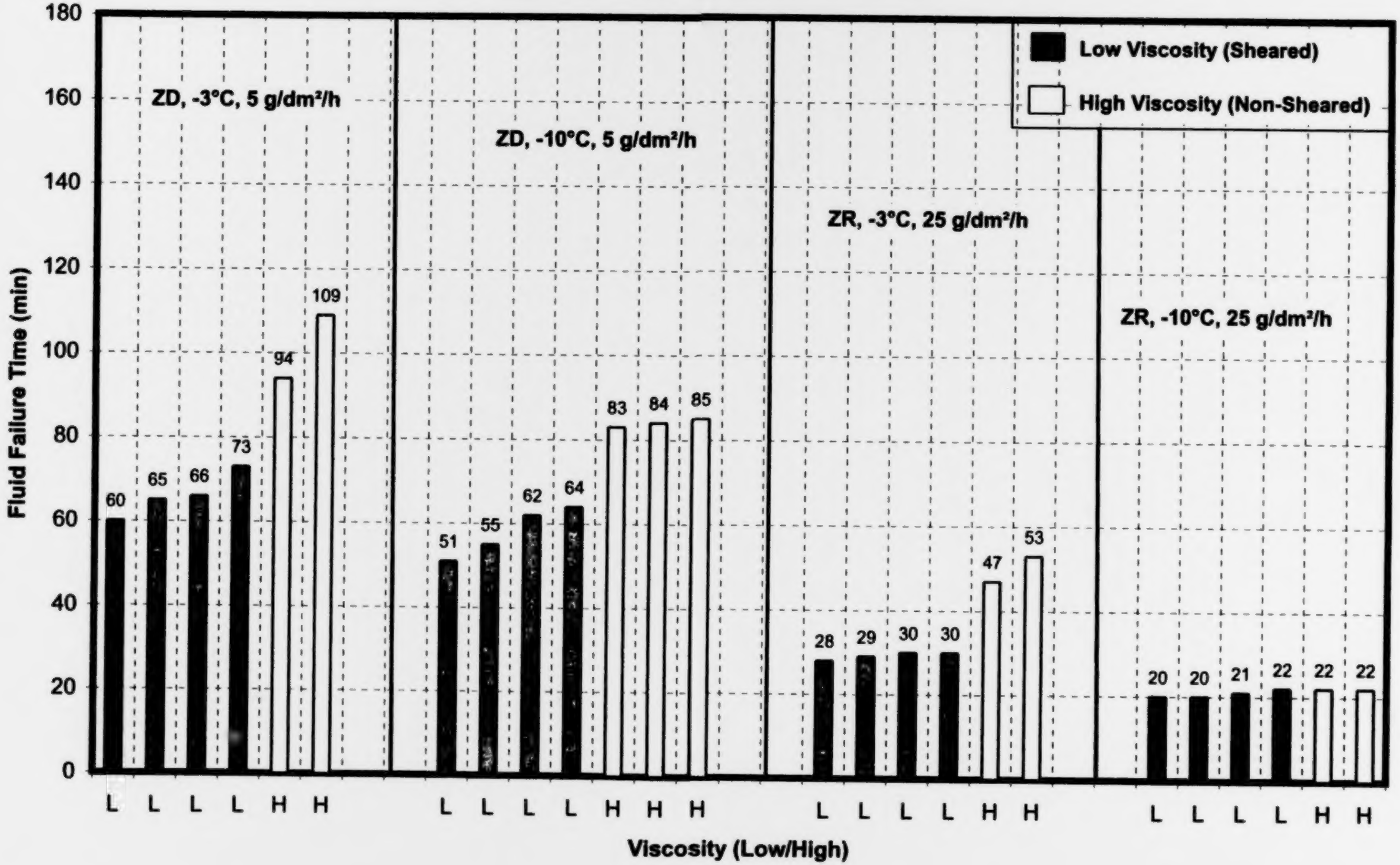
Figure 6.17 shows the results of tests conducted with Clariant Safewing MPIV 1957. In freezing drizzle at -3°C, the high viscosity sample outperforms the low viscosity sample by 53 percent on average. In freezing drizzle at -10°C, the high viscosity sample outperforms the low viscosity sample by 45 percent. In light freezing rain at -3°C, the average holdover time of the high viscosity sample is 71 percent superior to that of the low viscosity sample. In the final condition, light freezing rain at -10°C, the average holdover times of the two samples are similar.

Figure 6.18 shows the results of tests performed with Clariant Safewing Four, a certified propylene glycol-based Type IV fluid that will not be produced by the manufacturer in the upcoming year. In freezing drizzle at -3°C, the high viscosity sample displays only slightly improved holdover time performance than that of the low viscosity sample. At -10°C in freezing drizzle, the low viscosity sample actually outperforms the high viscosity sample by 11 percent. In light freezing rain at -3°C, the unsheared sample performed 16 percent better than the sheared sample. At -10°C in light freezing rain, the average holdover times of the two samples are similar.

Figure 6.19 shows the results of tests conducted with Type II Kilfrost ABC-II Plus. In freezing drizzle at -3°C, the high viscosity sample outperforms the low viscosity sample by 25 percent on average. In freezing drizzle at -10°C, the high viscosity sample outperforms the low viscosity sample by 34 percent. In light freezing rain at both temperatures, the average holdover times of the two samples are similar.

FIGURE 6.17

LOW vs HIGH VISCOSITY TESTS
CLARIANT SAFEWING MPIV 1957

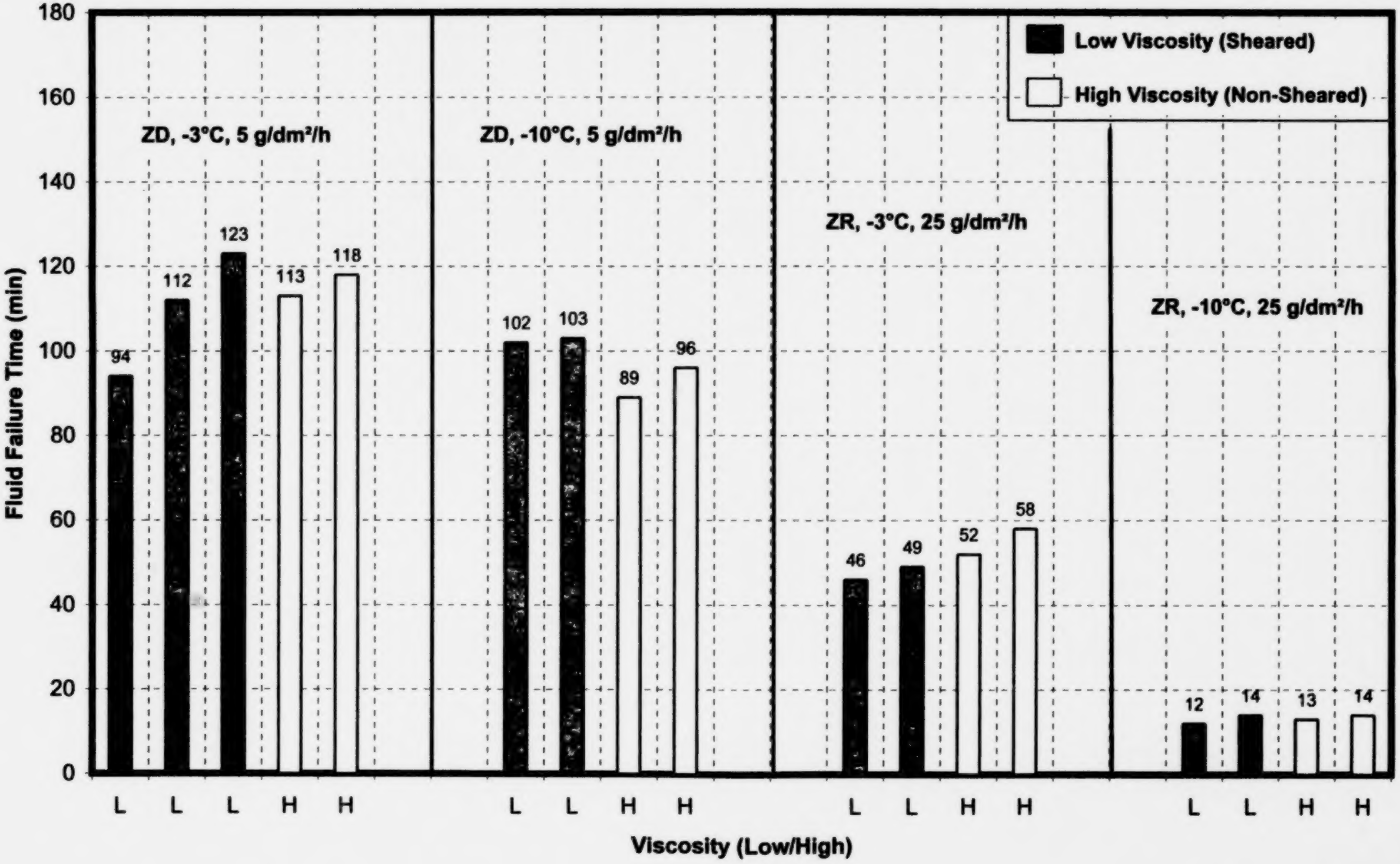


cm1514/report/hot_subs/Viscosity Comparison
At: CS1957

FIGURE 6.18

LOW vs HIGH VISCOSITY TESTS

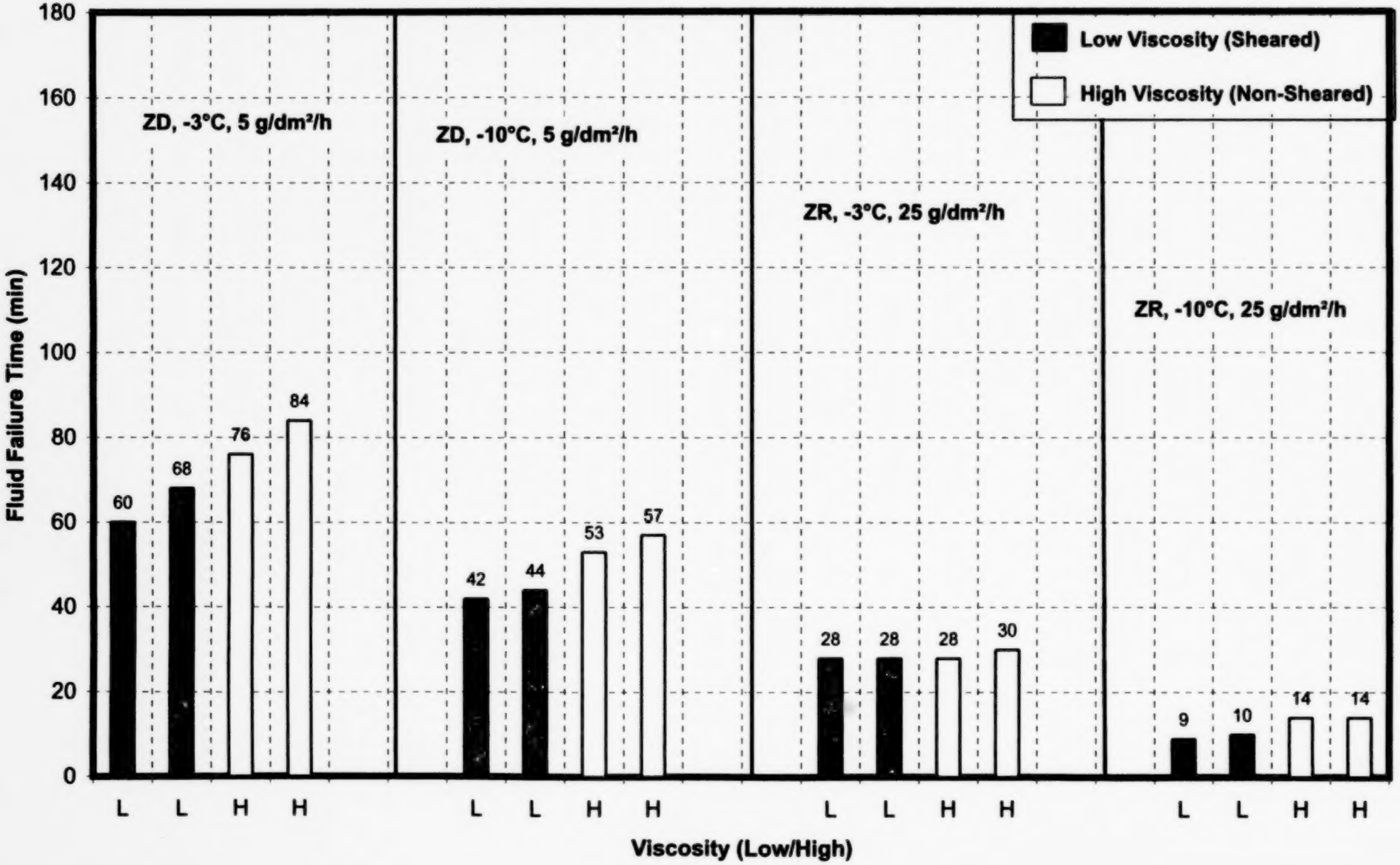
CLARIANT SAFEWING FOUR



cm1514/report/hot_subs/Viscosity Comparison
At: CSIV

FIGURE 6.19

LOW vs HIGH VISCOSITY TESTS
KILFROST ABC-II PLUS

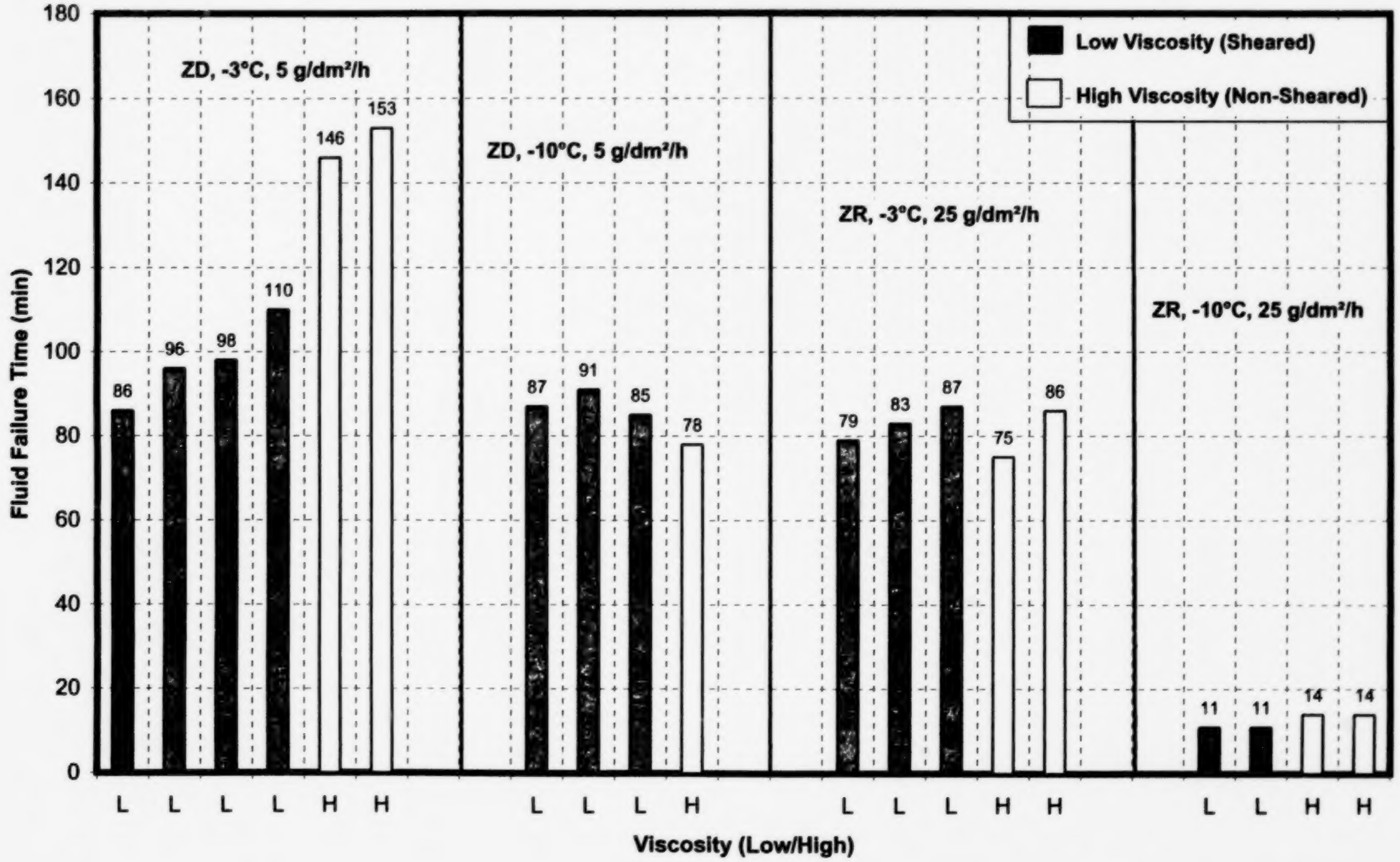


cm1514/report/hot_subs/Viscosity Comparison
At: KII+

FIGURE 6.20

LOW vs HIGH VISCOSITY TESTS

KILFROST ABC-S



cm1514/report/hot_subs/Viscosity Comparison
At: KABC-S

Figure 6.20 shows the results of tests performed with Kilfrost ABC-S. In freezing drizzle at -3°C, the unsheared sample outperforms the sheared sample by 53 percent on average. At -10°C in freezing drizzle, the low viscosity sample actually outperforms the high viscosity sample by 12 percent. In light freezing rain at -3°C, the unsheared and sheared samples perform similar. At -10°C in light freezing rain, the unsheared sample performs 27 percent better then the sheared sample.

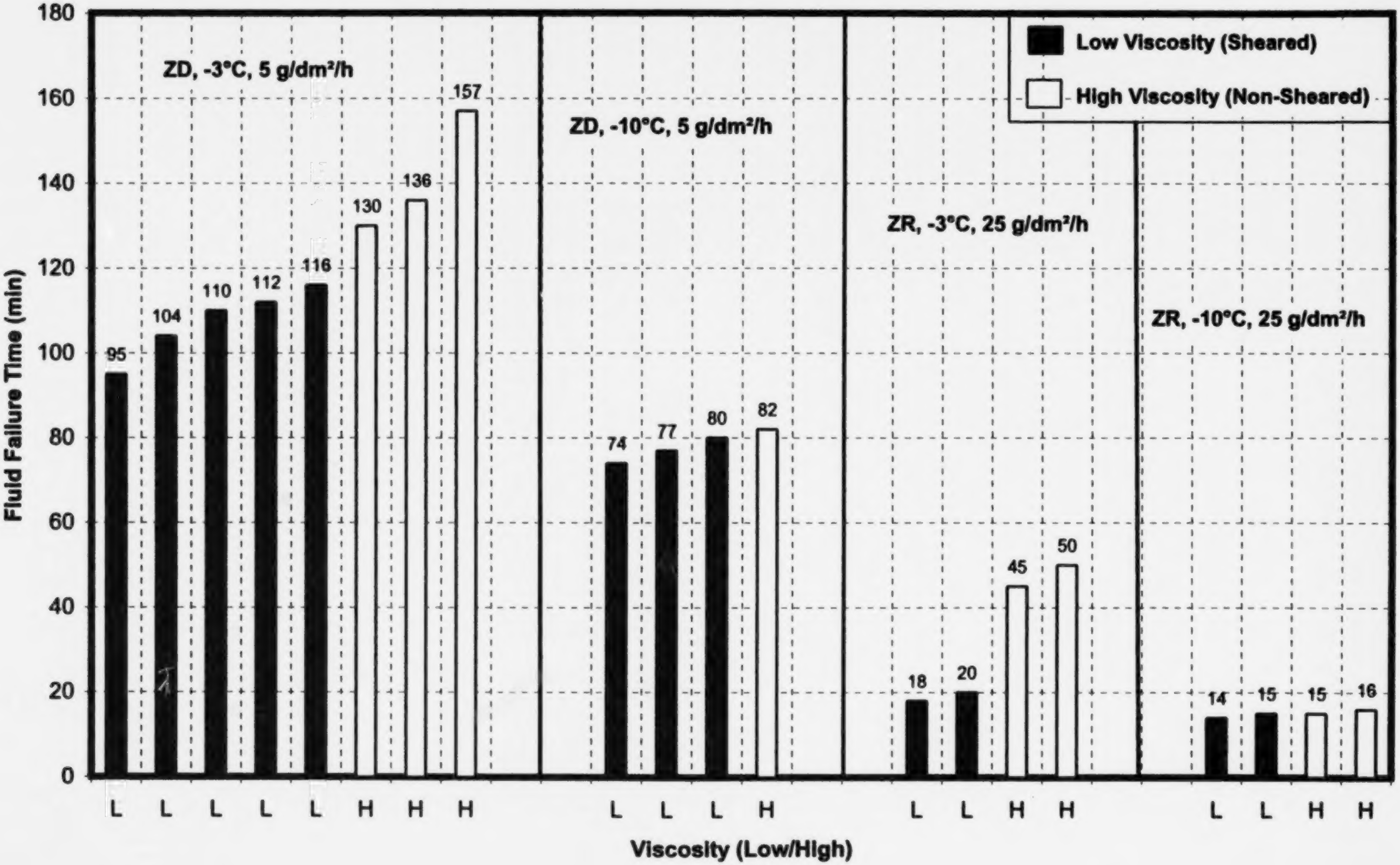
Figure 6.21 shows the results of tests conducted with Octagon Max-Flight. In freezing drizzle at -3°C, the unsheared sample outperforms the sheared sample by 32 percent on average. In freezing drizzle at -10°C, the high viscosity sample outperforms the low viscosity sample by 6 percent. In light freezing rain at -3°C, the average holdover time of the high viscosity sample is 150 percent superior to that of the low viscosity sample. In the final condition, light freezing rain at -10°C, the average holdover times of the two samples are similar.

In general, the high viscosity samples of the various anti-icing fluids tested outperformed the low viscosity samples. The high viscosity samples are more resistant to dilution and thus will provide better holdover time protection. In freezing drizzle at -10°C, the sheared Clariant Safewing Four and Kilfrost ABC-S outperformed the unsheared samples, because the high viscosity samples did not flow as freely and failures occurred in the upper fluid layers. Differences in formulations among the various anti-icing fluids are responsible for how the fluid theologies vary in response to lower temperatures, and are largely responsible for the different failure mechanisms observed.

The high and low viscosity samples of four out of the five fluids tested showed similar performance at -10°C in light freezing rain at a rate of 25 $g/dm^2/h$, due to the short duration of tests in this condition.

FIGURE 6.21

LOW vs HIGH VISCOSITY TESTS
OCTAGON MAXFLIGHT



cm1514/report/hot_subs/Viscosity Comparison
At: OCT

6.4 Evaluation of the Holdover Time Performance of a Reference Fluid

A reference fluid, Fluid X, was formulated in 1998-99 to enable comparisons between different laboratories conducting holdover time testing, and was tested by APS Aviation in natural and simulated precipitation conditions. The formulation of the fluid, which consists of 650 g of ethylene glycol, 350 g of deionized water, and 6 g of food grade xanthan gum, was prepared on two occasions by APS personnel. A third batch of Fluid X was prepared for APS by Union Carbide. The viscosities of the three samples were similar.

The holdover time results of tests conducted with Fluid X in simulated freezing drizzle, simulated light freezing rain, simulated freezing fog, rain on a cold-soaked surface, and natural snow appear in Figures 6.22 to 6.26.

Figure 6.27 shows the results of Fluid X tests conducted by APS in natural snow, by NCAR in artificial snow using the NCAR artificial snow generation system, and by AMIL using its artificial snowmaking machine. In general, the Fluid X holdover times generated by the NCAR snowmaker were well below the APS regression-generated values obtained from natural snow testing. The AMIL values (obtained at the SAE Workgroup on Laboratory Methods for Experimental Endurance Time Testing meeting in Chicoutimi) were below those obtained by NCAR. The data presented in Figure 6.27 suggests a lack of correlation between current artificial snow holdover time results and natural snow results, as well as between the current artificial snowmaking methods themselves.

FIGURE 6.22

EFFECT OF TEMPERATURE AND RATE OF PRECIPITATION ON ENDURANCE TIME

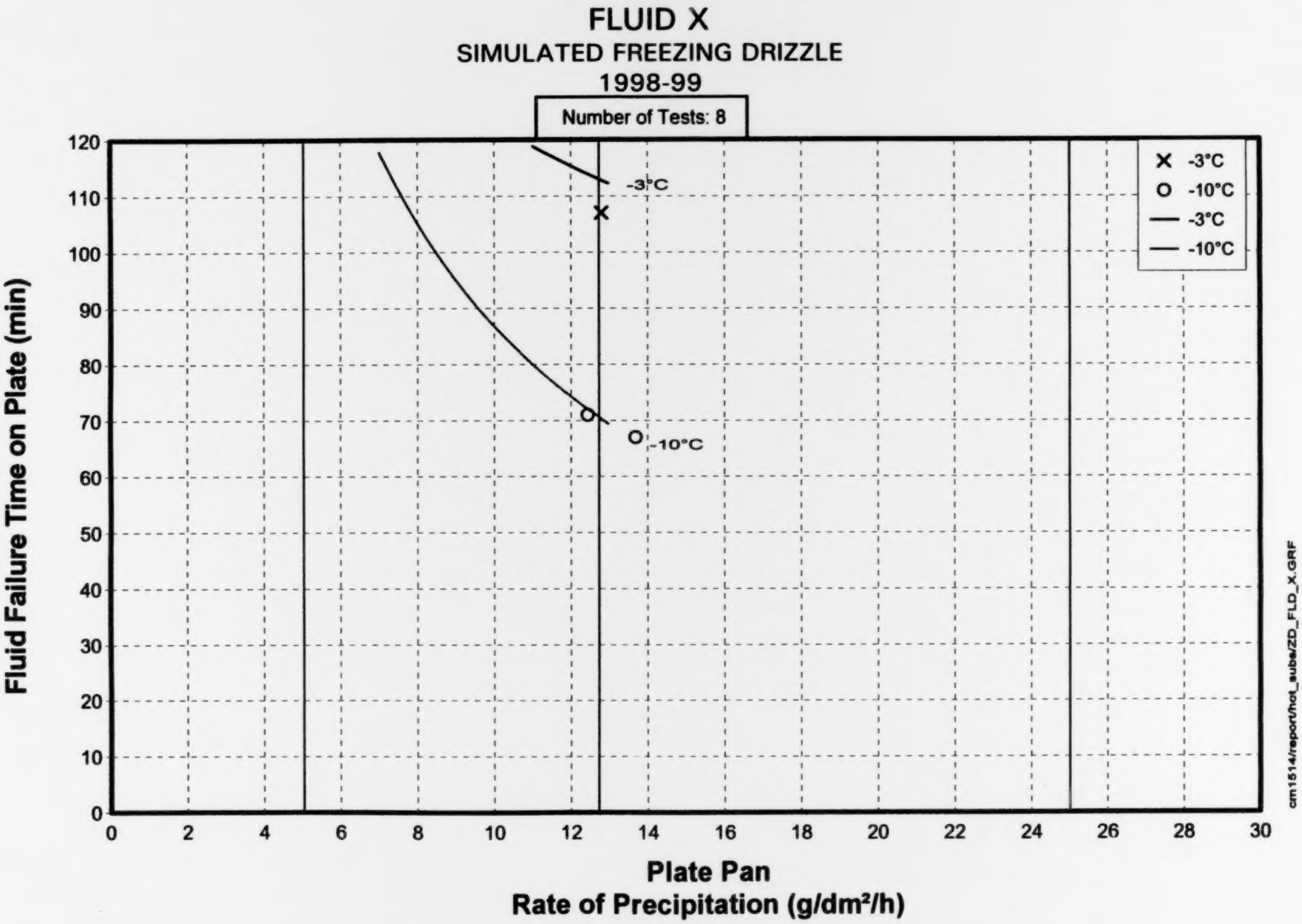
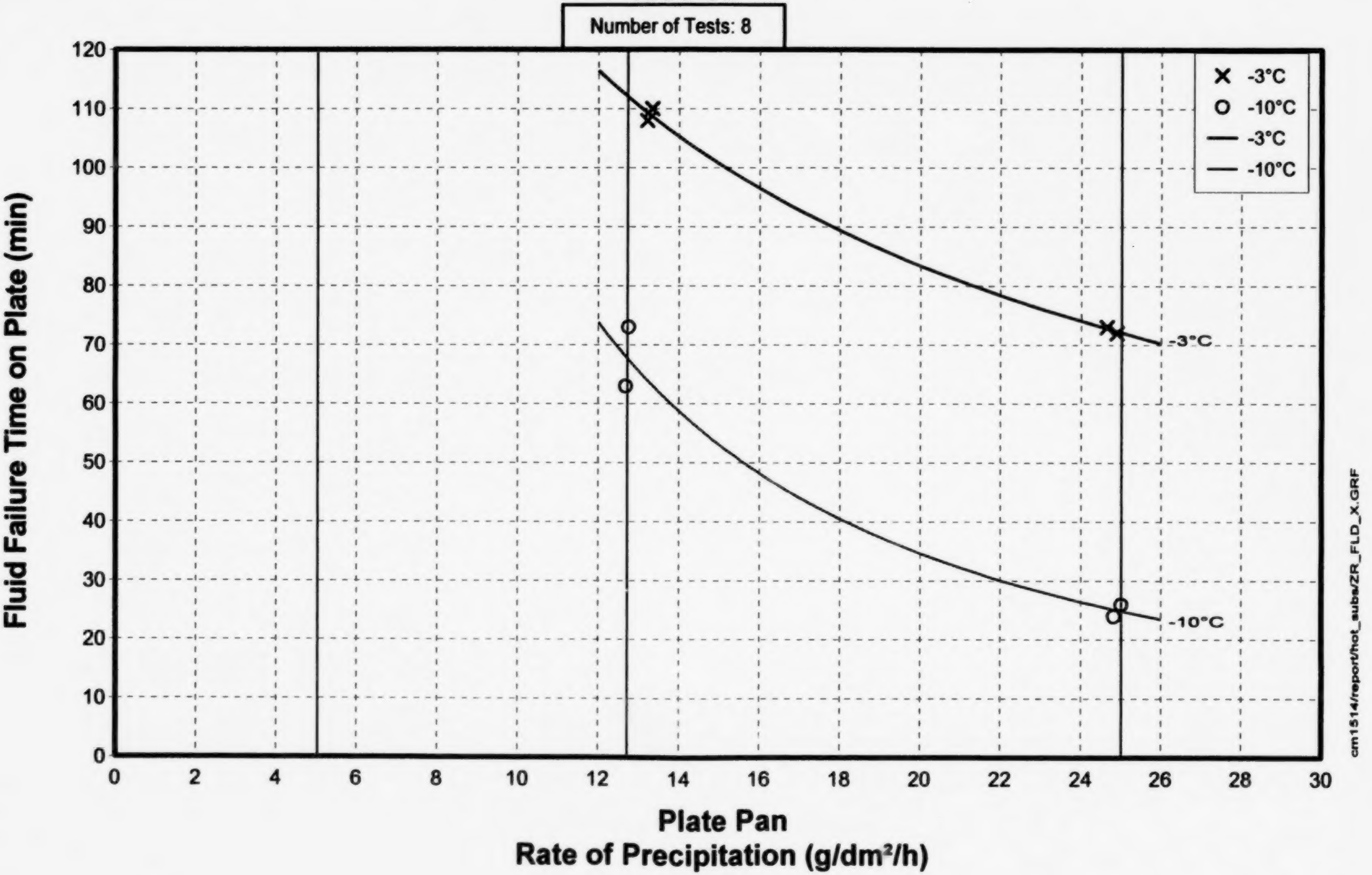


FIGURE 6.23
EFFECT OF TEMPERATURE AND RATE OF PRECIPITATION ON ENDURANCE TIME



FLUID X
SIMULATED LIGHT FREEZING RAIN
1998-99

FIGURE 6.24

EFFECT OF TEMPERATURE AND RATE OF PRECIPITATION ON ENDURANCE TIME

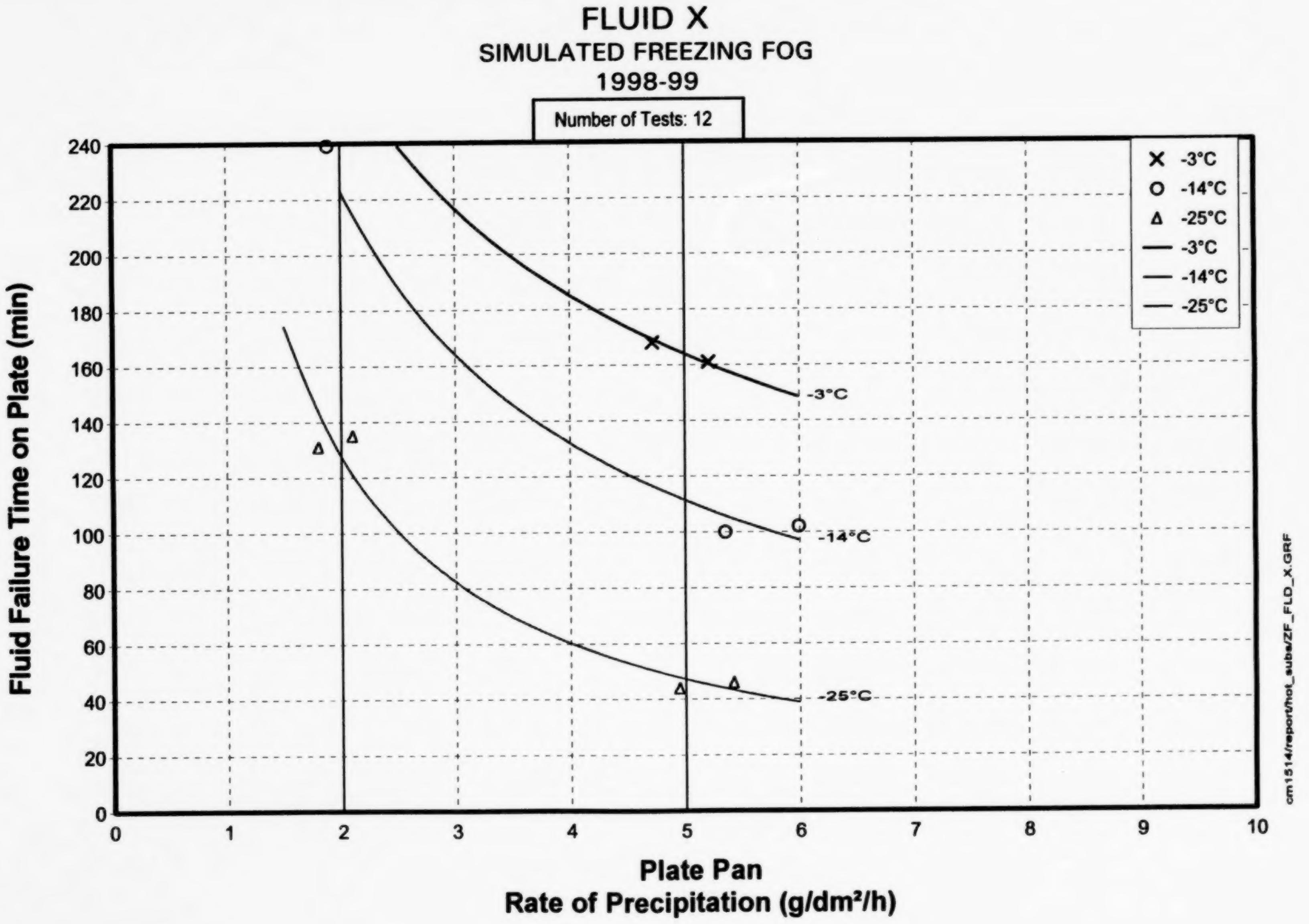


FIGURE 6.25
EFFECT OF RATE OF PRECIPITATION ON ENDURANCE TIME

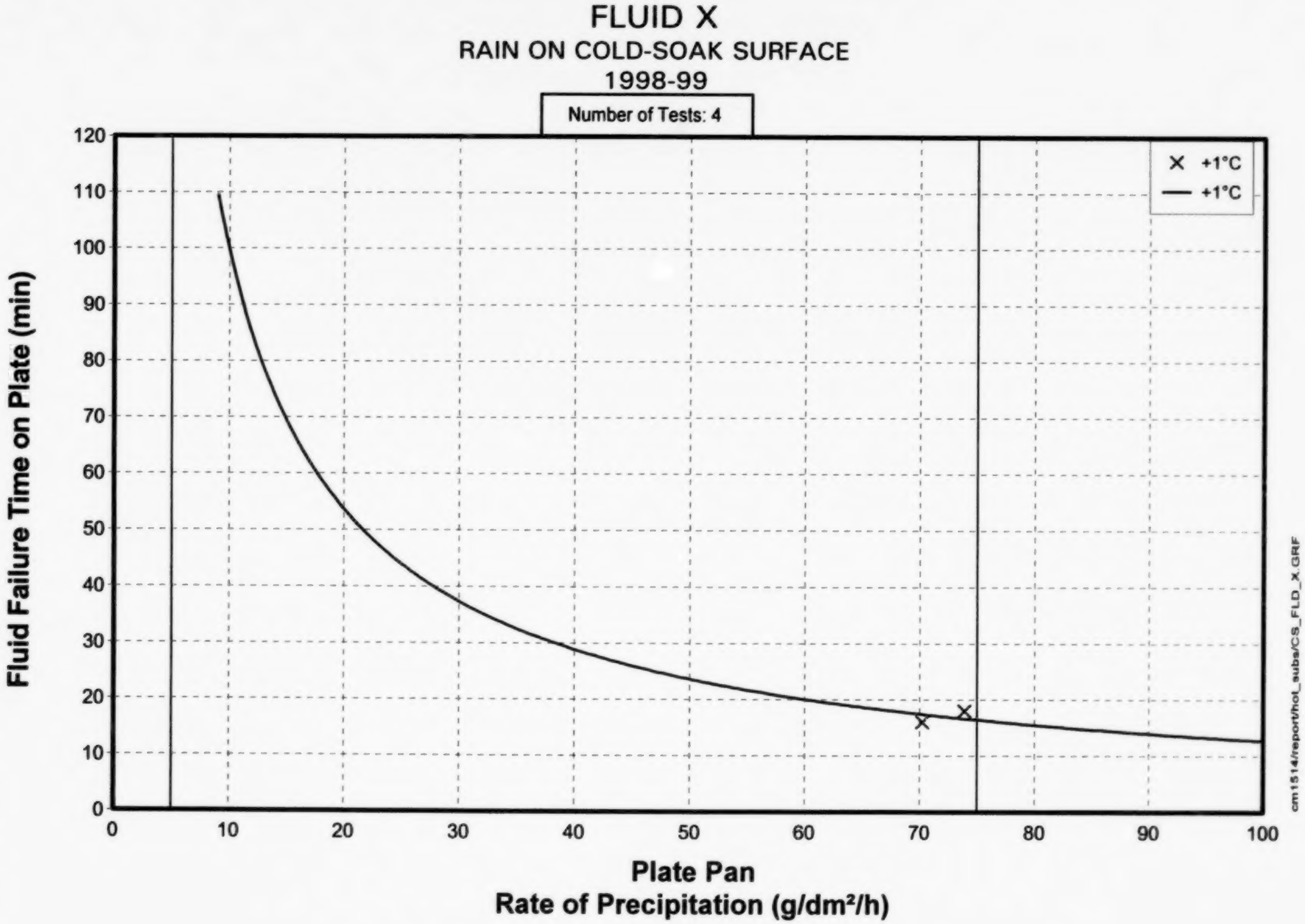


FIGURE 6.26
EFFECT OF TEMPERATURE AND RATE OF PRECIPITATION ON ENDURANCE TIME

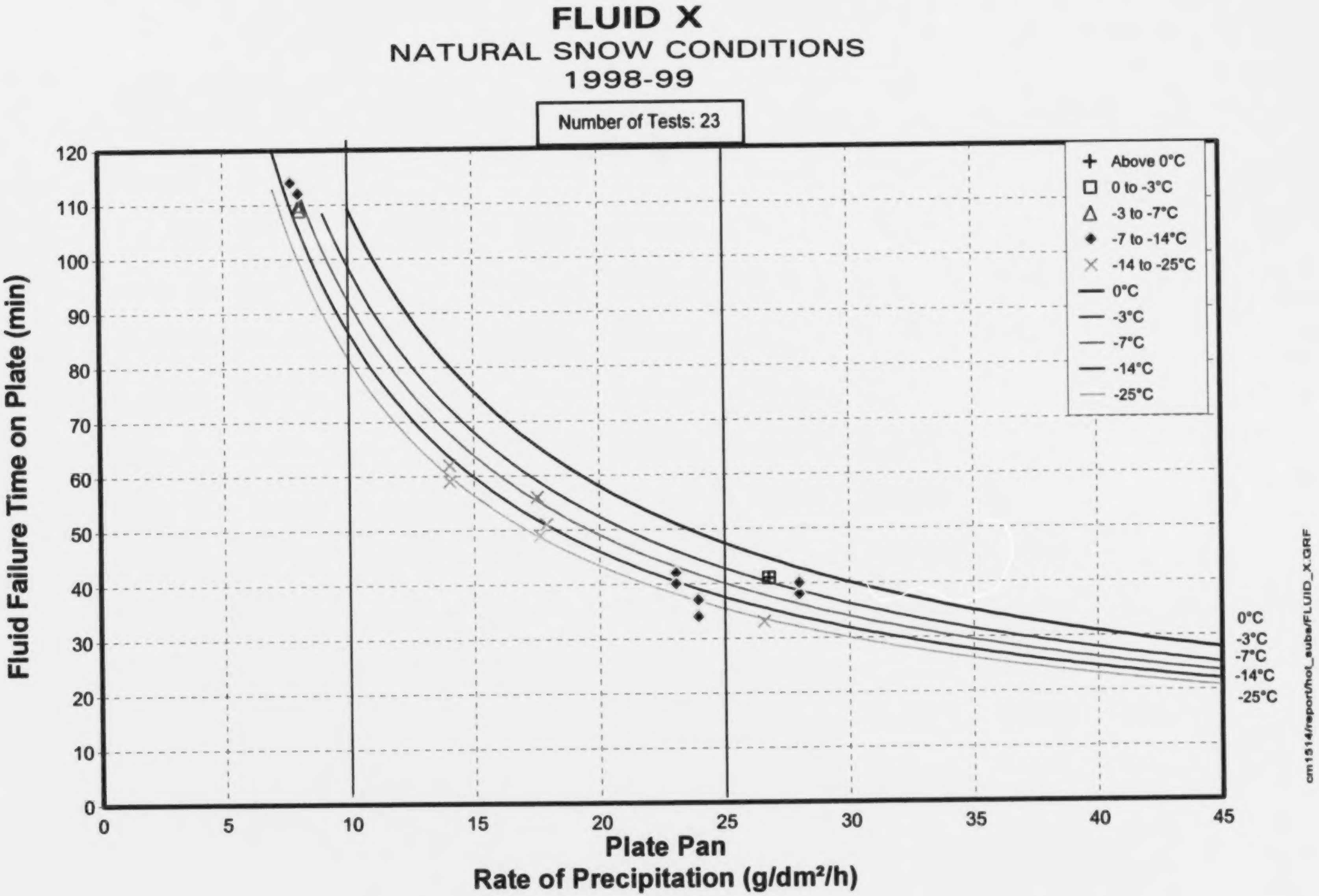
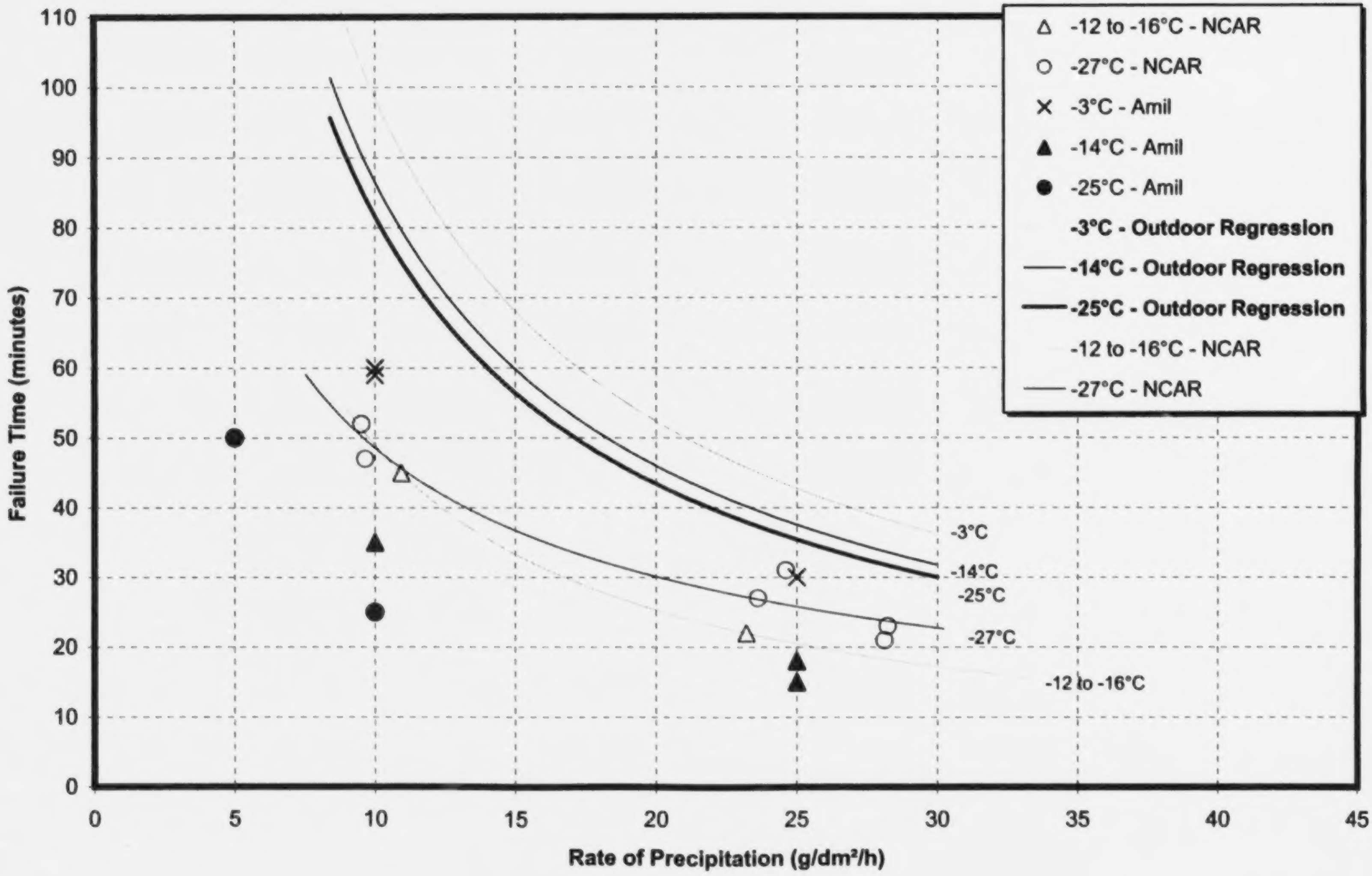


FIGURE 6.27

ARTIFICIAL SNOW DATA vs OUTDOOR DATA

FLUID X



6.5 Evaluation of Fog Deposition Rates in Natural Conditions

The objective of this study was to determine and correlate the range of deposition rates that occur naturally in fog with the 2 to 5 $g/dm^2/h$ range being used in environmental chambers. Fog deposition rates were to be collected on several occasions in periods of natural freezing fog. The procedure for fog deposition tests appears in Appendix M.

The test assembly included a precipitation collection pan inclined forward at 20° from the horizontal, wetted with Ultra+ Type IV fluid and mounted on the hood of an automobile travelling at a top speed of 30 km/h for consecutive 10-minute time intervals. The weight of the precipitation collection pan was to be measured after each 10-minute interval so that the fog deposition rate could be calculated. Modifications to pan inclination, vehicle speed, and test duration were to be made pending the results of preliminary tests. One APS test team member would conduct the test.

Tests were not conducted because the required weather conditions did not develop.

It is recommended that these tests be rescheduled for the following winter season.

6.6 Evaluation of Frost Deposition Rates in Natural Conditions

6.6.1 Frost Tests at Dorval Airport

6.6.1.1 Objective

The objectives of this study were to determine:

- Frost deposition rates in natural conditions; and
- Whether the rates of frost deposition were surface finish dependent.

6.6.1.2 Description of Test Procedures

Frost deposition tests were conducted on three separate occasions at the APS Dorval Airport test facility in December 1998, and January and February 1999.

The experimental procedure for frost tests on flat plates is shown in Appendix K. Several bare test surfaces with various compositions and/or finishes were prepared for the frost deposition tests. Each surface was pre-weighed to the nearest gram prior to being placed on a 10°-inclined test stand in active frost conditions and the start time was recorded. Following exposure to frost, the test surfaces were re-weighed. The final weights were calculated and recorded along with the end time of the test.

In addition to the bare surfaces tested, two separate plates were coated with fluid – one with Type I fluid, and the other with Type IV fluid – prior to exposure to frost. Fluid failure tests were carried out on these two plates using standard holdover time procedures.

Photo documentation of frost deposition tests was recorded using a 35 mm camera. Before and after photographs of each test surface were recorded.

6.6.1.3 Data Forms

Two data forms were employed during frost deposition tests:

- The End Condition Data Form (Appendix B, Table B-1) was used to record fluid failure results; and

- The Meteo/Plate Pan Data Form (Appendix B, Table B-2) contains information on the weather conditions and was used to record deposition rates.

6.6.1.4 Equipment

The following equipment was required for the frost deposition tests:

- 1.6 mm aluminum plates;
- 3.2 mm aluminum plates;
- Kevlar composite plate;
- Carbon fibre plate;
- Glass fibre plate;
- 0.5 mm aluminum honeycomb core plate;
- Precipitation rate pans;
- Test stand;
- Weigh scale; and
- 35 mm camera.

Several painted 1.6 mm aluminum plates were also among the surfaces tested during the past year. Colours included red, green, metallic silver and white.

The fluids used in testing were Union Carbide Type I XL54 and Type IV Octagon Max-Flight.

6.6.1.5 Personnel

Two APS personnel, a photographer and a plate observer, were required to conduct frost deposition tests.

6.6.1.6 Overview of Test Sessions

Frost deposition tests were conducted on three occasions at the Dorval Airport test facility.

Run #1 was conducted on December 8, 1998. The test panels included a standard 3.2 mm (1/8") aluminum plate, a 1.6 mm (1/16") aluminum plate, a 1.6 mm aluminum plate (painted green), a 1.6 mm aluminum plate (painted red), a 1.6 mm aluminum plate (painted white), a carbon fibre plate, and a standard aluminum plate pan coated with Type IV fluid. Test panels were weighed, placed on a test stand, and exposed to a three-hour period of active frost before being re-weighed. The ambient temperature was -5°C.

Run #2 was conducted on January 8, 1999. The test panels included a standard 3.2 mm aluminum plate, a 1.6 mm aluminum plate (painted green), a 1.6 mm aluminum plate (painted red), a 1.6 mm aluminum plate (painted white), a 1.6 mm aluminum plate (painted silver), a carbon fibre plate, a 0.5 mm (0.020") aluminum plate backed with honeycomb, and a standard aluminum plate pan coated with Type IV fluid. Test panels were weighed, placed on a test stand, and exposed to three consecutive two-hour periods of active frost. The panels were re-weighed at two-hour intervals. The ambient temperature was -16°C.

The final test, Run #3, was conducted at the Dorval Airport test facility during the night of March 15/16, 1999. Eight surfaces, a 3.2 mm aluminum plate, a 1.6 mm aluminum plate (painted green), a 1.6 mm aluminum plate (painted red), a 0.5 mm aluminum plate backed with honeycomb, a carbon fibre plate, a carbon fibre plate painted silver, and two aluminum plate pans, were weighed, placed on a test stand, and re-weighed following a two-hour exposure period to active frost conditions.

6.6.1.7 Description of Data Collected and Analysis

Frost deposition rates were calculated by dividing the difference between the start and end weights of the test surfaces (in grams) by the number of hours that the surfaces were exposed to frost conditions. The result was then divided by the area of the test surface (in dm^2). The frost deposition is expressed in $g/dm^2/h$.

Results from Run #1 indicate that frost deposition rates were in the range of 0 to 0.25 $g/dm^2/h$, depending on the test surface. The highest deposition rate was experienced by the plate pan coated with Type IV fluid (0.25 $g/dm^2/h$). Rates observed on the white, red and green painted aluminum 1.6 mm (1/16") plates were 0.09, 0.05 and 0.05 $g/dm^2/h$, respectively. The carbon fibre plate collected frost at a rate of 0.07 $g/dm^2/h$. No accumulation of frost was observed on the 3.2 mm (1/8") and 1.6 mm standard aluminum plates.

Results from Run #2 showed average frost deposition rates in the range of 0 to 0.12 $g/dm^2/h$. All test surfaces were exposed to frost conditions for three 2-hour periods. The highest deposition rates were again experienced by the plate pan, which saw an average deposition rate of 0.12 $g/dm^2/h$. The carbon fibre plate had an average deposition rate of 0.10 $g/dm^2/h$, while the 0.5 mm (0.020") aluminum plate backed with honeycomb had an average rate of 0.04 $g/dm^2/h$. Rates observed on the white, red, silver and green painted aluminum 1.6 mm plates were 0.07, 0.08, 0.06 and 0.06 $g/dm^2/h$, respectively. Again, no accumulation of frost was detected on the standard 3.2 mm aluminum plate.

Results from Run #3 showed frost deposition rates in the range of 0 to 0.22 $g/dm^2/h$. The highest rates of deposition are, once again, achieved by the plate pans with an average rate of 0.22 $g/dm^2/h$. The carbon fibre plates (bare and painted) had rates of 0.19 and 0.17 g/dm2/h. Rates observed on the red and green painted aluminum 1.6 mm (1/16") plates were both 0.07 g/dm2/h. The 0.5 mm (0.020") aluminum plate backed with honeycomb and the 3.2 mm (1/8") bare aluminum plate collected no frost whatsoever.

Conclusions as to why unpainted aluminum surfaces remained frost-free are not easy to formulate. Three parameters that might be mitigating factors in these results are related to radiation or surface effects, as all temperatures of the test surfaces were equilibrated with the outside air temperature. The three parameters are:

- The surface material's emissivity;
- The surface roughness; and
- The photoelectric effect.

Temperature probes should be mounted on bare aluminum plates and painted aluminum plates in all future frost deposition tests. This would allow the temperature profiles of bare and painted aluminum plates in active frost conditions to be compared and possibly explain why unpainted surfaces remain frost-free.

6.6.2 Frost Tests at Northern Airports

A procedure was developed in 1998-99 for frost deposition tests at northern airports (see Appendix L). Tests were planned for Thompson, Manitoba, and an individual was recruited. The various materials required for the conduct of these tests were delivered to the individual along with the test procedure. Despite several attempts, no data were gathered.

6.7 Evaluation of Ice-Phobic Materials

A preliminary set of tests aimed at evaluating deicing and anti-icing fluid behaviour when applied to surfaces treated with an ice phobic material, Dampney's Endcor 6400 Fuoro II Coating System, were to be conducted during the 1998-99 test season. The procedure for these tests appears in Appendix N.

Test panels were provided to Dampney for coating purposes; however, they were never coated. As a result, no tests with ice phobic materials were conducted.

6.8 Aircraft Icing-Related Accident/Incident Database

Under contract to TDC, APS Aviation compiled an excel database of world aviation icing-related accidents and incidents. In order to complete this task, information was obtained from several existing databases: Eurice, Flight Safety Foundation, ICAO, NASA, National Transportation Safety Board, Transport Canada, and RAA/FAA UIRP (Unusual Icing Report).

Accident incident reports were examined in order to classify the icing event in one of six categories: engine icing (EI), ground icing (GI), structural icing (SI), runway icing (RI), deteriorating weather (DW) and unknown (UN). The events were then sorted by date.

The complete database appears in Appendix S.

7. CONCLUSIONS

7.1 Holdover Time Determination

7.1.1 Changes to the Holdover Time Tables

The viscosity of the fluid sample used in holdover time testing, as measured by APS personnel, now appears on the fluid-specific holdover time table for any given anti-icing fluid. The instrument spindle, chamber size, temperature and RPM are also documented along with the viscosity measurement. In order for the fluid-specific values of a fluid to be valid, operators must ensure that the viscosity of the fluid used is superior to the published viscosity of that fluid, using the same viscosity measurement method published.

An additional column was added to the holdover time tables (for use in 1999-2000 winter operations) that covers the following precipitation conditions:

- Heavy snow;
- Snow pellets;
- Snow grains;
- Ice pellets;
- Moderate and heavy freezing rain; and
- Hail.

A cautionary note, which states that no holdover time guidelines exist for these categories of precipitation, was placed in this column.

7.1.2 Type IV Fluids

The 1998-99 holdover time test program concentrated on the determination of holdover times for one new Type IV fluid, as well as the re-testing of four certified Type IV fluids, using fluid samples representative of the manufacturers' lowest recommended on-wing viscosity.

The results of these tests revealed a wide variation in performance properties among the different fluid brands. In the determination of fluid holdover times, the data for each fluid and each cell of the tables were subjected to a regression analysis. From the results of the analyses, the SAE Type IV fluid holdover time table was devised, wherein each cell in the table contains the holdover times of the poorest performing fluid brand(s). Due to the widely varying performance of the Type IV fluids tested, fluid-specific holdover time tables were developed. All categories of precipitation, with the exception of frost, were selected to take advantage of enhanced holdover times for individual fluids.

7.1.2.1 Snow

A comparison of the Type IV fluid holdover times approved for operational use in 1998-99 in natural snow to those appearing in this year's (1999-2000) SAE Type IV fluid table reveals that four reductions have been made to the generic holdover time table. One low-viscosity fluid in its neat concentration is responsible for changes to both the upper and lower holdover time values in two cells (above 0°C, and from 0°C to -3°C).

7.1.2.2 Freezing Drizzle

Four changes were made to the holdover times appearing in the 1998-99 SAE Type IV table in freezing drizzle conditions. The changes occurred in the -3°C to -10°C temperature range for neat and 75/25 fluid, and in both cases, the upper and lower limit holdover times were reduced by 5 minutes.

7.1.2.3 Light Freezing Rain

Holdover time changes were made to four cells in the SAE Type IV table in light freezing rain conditions. The changes occurred in the above 0°C and 0°C to -3°C cells for neat fluid, and the -3°C to -10°C cells for neat and 75/25 fluid. In both the above 0°C and 0°C to -3°C cells, one fluid is responsible for a 10-minute reduction in the lower holdover times and a 15-minute reduction in the upper holdover times. In the -3°C to -10°C cells for neat and 75/25 fluid, the same fluid is responsible for a 5-minute reduction in the lower holdover time limit.

7.1.2.4 Freezing Fog

1998-99 marked the first time that testing in freezing fog conditions was conducted at the lower precipitation rate of 2 $g/dm^2/h$. As a result, several of the upper holdover times were reduced, in some cases significantly. Overall, 12 changes were made to the SAE Type IV holdover time table in the freezing fog column.

In the above 0°C and 0°C to -3°C cells for neat fluid, one fluid is responsible for a 55-minute reduction in the lower holdover time and a 45-minute reduction in the upper holdover time. In the above 0°C and 0°C to -3°C cells for 75/25 and 50/50 fluid, one fluid is responsible for 15 minute and 10-minute reductions in the upper holdover times, respectively. In the -3°C to -14°C cell for neat fluid, the upper holdover time was reduced by one hour and 30 minutes, due to the results of one fluid. In the -3°C to -14°C cell for 75/25 fluid, the upper and lower holdover times were reduced by one hour and 5 minutes, respectively, based on the results of two fluids. In the final cell of the freezing fog column (-14°C to -25°C for neat fluid), the upper holdover time was reduced by one hour and 20 minutes. Three fluids are responsible for this reduction.

Furthermore, fluid-specific holdover times for freezing fog were adopted for the first time for all fluids tested in 1998-99. Two fluids for which fluid-specific tables will be available for use during the 1999-2000 winter season (Clariant MPIV 2001 and SPCA AD-480), were not tested during the past year. As a result, the SAE holdover times appear in the freezing fog columns of the fluid-specific tables for both of these fluids.

7.1.2.5 Rain on a Cold-Soaked Wing

No changes were made to the SAE holdover times in the rain on a cold-soaked wing condition. As was the case in freezing fog, fluid-specific holdover times for rain on a cold-soaked wing were adopted for the first time for all fluids tested in 1998-99. Two fluids for which fluid-specific tables will be available for use in 1999-00, Clariant MPIV 2001 and SPCA AD-480, were not tested during the past year. As a result, the SAE holdover times appear in the rain on a cold-soaked wing columns of the fluid-specific tables for both of these fluids.

7.1.3 Type II Fluids

One Type II fluid, Kilfrost ABC-II Plus was tested during the 1998-99 test season. Due to the performance variations exhibited by the Kilfrost Type II fluid in the different temperature ranges, a fluid-specific holdover time table was developed for this fluid, the first of its kind for a Type II fluid.

7.1.3.1 Natural Snow

Two changes were made to the current SAE Type II generic table, one based on the results of tests conducted with Kilfrost ABC-II Plus (a 5-minute upper limit reduction in the -3°C to -14°C cell for neat fluid), the other due to inferior Type IV results in the corresponding cell of the SAE Type IV table. In general, the performance of the new Kilfrost fluid is superior to the generic Type II fluid holdover times at warm temperatures (above -3°C).

7.1.3.2 Freezing Drizzle

Six changes were made to the generic or SAE Type II fluid holdover time table from last year. The lower limit in the above 0°C and 0°C to -3°C cells for 50/50 fluid were reduced by 5 minutes. In the colder cells of the freezing drizzle column (-3°C to -10°C), all of the holdover time limits were reduced.

7.1.3.3 Light Freezing Rain

One change was made to the current SAE Type II fluid holdover timetable in light freezing rain conditions. In this case, the upper holdover time limit in the -3°C to -10°C cell for 75/25 fluid was reduced by 5 minutes.

7.1.3.4 Freezing Fog

Tests conducted in freezing fog prior to 1998-99 did not use the lower precipitation rate limit of 2 $g/dm^2/h$, and as such, several reductions were made to the Type II SAE fluid holdover time table in freezing fog conditions. In total, eight changes were made due to the performance of the Kilfrost fluid. Four other changes were due to reductions in the Type IV fluid holdover time table.

In the above 0°C cell for neat fluid, the upper and lower holdover time limits were reduced by 45 and 10 minutes, respectively, based on the holdover time results of Type IV fluid. In the above 0°C cell for 75/25 fluid, a reduction of 15 minutes in the upper holdover time occurred based on the 1998-99 Type IV results. For 50/50 fluid above 0°C, two additional changes were made: a 5-minute reduction in the lower holdover time due to the performance of Kilfrost ABC-II Plus fluid, and a 10-minute reduction in the upper holdover due to Type IV fluid results.

All of the subsequent changes to the Type II table are due to the performance of Kilfrost ABC-II Plus. In the 0°C to -3°C cell for 50/50 fluid, the lower holdover time was reduced by 10 minutes. In the -3°C to -14°C cell for neat fluid, the upper and lower holdover times were reduced by 25 minutes and 5 minutes, respectively. In the -3°C to -14°C cell for 75/25 fluid, both the upper and lower holdover times were reduced by 5 minutes. In the final cell of the freezing fog column, -14°C to -25°C for neat fluid, the upper holdover time was reduced by one hour and 10 minutes, while the lower time was reduced by 5 minutes.

7.1.3.5 Rain on a Cold-Soaked Wing

Only one change occurred in the rain on a cold-soaked wing column. For neat fluid, the lower holdover time limit was reduced based on the results of Kilfrost ABC-II Plus.

7.1.4 Type I Fluids

In general, the Type I holdover time results agreed with the current SAE Type I holdover time guidelines. The upper values in freezing fog may need to be re-examined, due to the fact that a specific precipitation rate of 2 g/dm^2/h was used for the first time in holdover time testing. The results obtained in simulated snow were inconclusive, because the artificial snowmaking method has not yet been approved for use.

In general, the holdover time performances of the six new Type I fluids were similar to those of the two reference fluids

7.1.5 Type III Fluids

No Type III fluids were available during the past season and therefore no Type III tests were performed. A Type III holdover time table exists; however, the values need to be substantiated since the table was generated using a fluid that is no longer commercially available.

7.2 SUPPLEMENTARY TESTS

7.2.1 Evaluation of Recycled Fluids

- Holdover time tests conducted with the Inland Duragly-E and Duragly-P recycled fluids showed them to exhibit performance equivalent to current commercially available Type I fluids;

- The holdover times of Type IV fluids are generally reduced slightly when applied over an undercoat of Type I or recycled fluids; and

- Both recycled fluids appear to be compatible with commercial Type IV fluids when intended as first-step fluids in a two-step application. No single undercoat fluid appeared to have a significantly worse effect on Type IV fluid holdover time in all conditions.

7.2.2 Influence of Fluid Viscosity on Holdover Time

Tests conducted using low and mid-range viscosity samples from the same fluid manufacturer showed that viscosity does affect the holdover time of a fluid. A high viscosity sample is more resistant to dilution and will generally outperform a low viscosity sample, except at colder temperatures (for certain fluids), where the fluid manufacturer's high viscosity sample did not flow as freely and failures occurred in the upper fluid layer.

7.2.3 Evaluation of the Holdover Time Performance of a Reference Fluid

Holdover time tests were conducted with a reference fluid (Fluid X) in all natural and simulated precipitation conditions. The results of Fluid X tests conducted by APS in natural snow, NCAR in simulated snow using the NCAR artificial snow generation system, and AMIL using its simulated snowmaking machine were compared. In general, the Fluid X holdover times in simulated snow are well below the APS regression-generated values obtained from natural snow testing. The AMIL values are even below those obtained by NCAR. The data suggests a lack of correlation between current simulated snow holdover time results and natural snow results, as well as between the current simulated snow methods themselves.

7.2.4 Evaluation of Frost Deposition Rates in Natural Conditions

From the results of these tests, it is possible to conclude that:

- Frost rates measured ranged from 0 to 0.25 g/dm^2/h;
- The rate of frost deposition is surface-dependent;
- Frost does not readily accumulate on bare aluminum surfaces;
- Frost does accumulate on painted aluminum surfaces; and
- Composite surfaces and honeycomb-backed surfaces (similar to aircraft flight controls) are prone to frost accumulation.

The rate of frost deposition varied from 0.05 to 0.09 g/dm^2/h on painted surfaces to 0 g/dm^2/h on unpainted aluminum surfaces.

8. RECOMMENDATIONS

The following section provides a series of detailed recommendations based on the test results and conclusions.

8.1 Holdover Time Tests

It is recommended that:

- Any new Type IV fluids be evaluated over the entire range of conditions of the holdover time tables;
- The holdover time table for Type III fluids be re-evaluated if new Type III fluids become available for testing in the 1999-2000 test season;
- Type II fluid-specific tables be generated for previously certified Type II fluids;
- Type I fluids, tested as part of the 1998-99 test program in simulated conditions, be tested in natural snow conditions, in order to compare the holdover time results in natural and simulated snow;
- Type I holdover time tests be conducted in natural snow conditions using Type I fluids of various temperatures in order to determine the influence of the application temperature on holdover time;
- Preliminary holdover time tests in frost conditions be conducted as part of the winter holdover time test program; and
- Additional testing be conducted using the improved NCAR artificial snow generation system to compare holdover time results in natural and simulated snow.

8.2 Supplementary Tests

8.2.1 Influence of Fluid Viscosity on Holdover Time

Fluid viscosity appears to have a substantial effect on fluid holdover time. In the future, all fluid manufacturers should ship fluids according to the guidelines outlined in the sample selection procedures devised by the SAE in 1998-99 and slated for inclusion in AMS 1424 and 1428. Manufacturers should refer to these documents prior to any future delivery of fluids for holdover time purposes.

8.2.2 Evaluation of the Holdover Time Performance of a Reference Fluid

It is recommended that future holdover time tests be conducted using the reference fluid in natural snow in order to complete the database established from limited testing in 1998-99.

8.2.3 Evaluation of Fog Deposition Rates in Natural Conditions

In 1998-99, fog deposition tests were not conducted because the required weather conditions did not develop. It is recommended that tests be rescheduled for the following winter season.

8.2.4 Evaluation of Frost Deposition Rates in Natural Conditions

Temperature probes should be mounted on bare aluminum plates and painted aluminum plates in a series of frost deposition tests. This would allow the temperature profiles of bare and painted aluminum plates in active frost conditions to be compared and possibly explain why unpainted surfaces remain frost-free.

A procedure was developed in 1998-99 for the conduct of frost deposition tests at northern airports. Despite attempts to conduct the tests in Thompson, Manitoba, no data were gathered. It is recommended that the same tests be rescheduled for the upcoming winter test season.

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APPENDIX A

WORK STATEMENT

APPENDIX A

TRANSPORTATION DEVELOPMENT CENTRE

WORK STATEMENT

AIRCRAFT AND FLUID HOLDOVER TIME TESTS FOR WINTER 98/99

(December 1998)

1. INTRODUCTION

Following the crash of a F-28 at Dryden in 1989 and the subsequent recommendations of the Commission of Inquiry, the Dryden Commission Implementation Project (DCIP) of Transport Canada (TC) was set up. Together with many other regulatory activities an intensive research program of field testing of deicing and anti-icing fluids was initiated with guidance from the international air transport sector through the Society of Automotive Engineering (SAE) G-12 Committee on Aircraft Ground De/Anti-icing. As a result of the work performed to date Transport Canada and the US Federal Aviation Administration (the FAA) have been introducing holdover time regulations and the FAA has requested that the SAE, continue its work on substantiating the existing ISO/AEA/SAE Holdover Time (HOT) tables (TC research representing the bulk of the testing).

The times given in HOT Tables were originally established by the Association of European Airlines based on assumptions of fluid properties, and anecdotal data. The extensive testing conducted initially by the DCIP R&D Task Group and subsequently by its successor Transport Canada, Transportation Development Centre (TDC) Aviation Winter Operations R&D (AWORD) Group has been to determine the performance of fluids on standard flat plates in order to substantiate the times or, if warranted, to recommend changes.

TDC has undertaken most of the field research and much other allied research to improve understanding of the fluid HoldOver Times. Most of the HOT table cells been substantiated, however low temperatures have not been adequately explored and further tests are needed.

The development of ULTRA by Union Carbide stimulated all the fluid manufacturers to produce new long lasting anti-icing fluids defined as Type IV. All the Type IV fluids were upgraded in early 1996 and therefore all table conditions need to be re-evaluated and the table revised if necessary. Certain special conditions for which advance planning is particularly difficult such as low temperatures with precipitation, rain or other precipitation on cold soaked surfaces, and precipitation rates as high as 25 gm/dm²/h need to be included in the data set. All lead to the need for further research.

Although the Holdover tables are widely used in the industry as guides to operating aircraft in winter precipitation the significance of the range of time values given in each cell of the table is obscure. There is a clear need to improve the understanding of the limiting weather conditions to which these values relate.

An important effort was made in the 94/95 and 95/96 seasons to verify that the flat plate data were representative of aircraft wings. Airlines cooperated with DCIP by making aircraft and ground support staff available at night to facilitate the correlation testing of flat plates with performance of fluids on aircraft. An extension of this testing was to observe patterns of fluid failure on aircraft in order to provide data to assist pilots with visual determination of fluid failure, and to provide a data to contamination sensor manufacturers. The few aircraft tests made to validate the flat plate tests were inconclusive and more such tests are needed. Additional tests testing with hot water for special deicing conditions were not completed. All these areas are the subjects for the further research that is planned for the 98/99 winter.

The primary objective of 97/98 testing was the performance evaluation of new and previously qualified Type IV fluids over the entire range of conditions encompassed by the holdover time tables. The effect of different variables on the fluid holdover time, in particular the effect of fluid viscosity, was examined and deemed to be significant. As a result, any future Type IV fluid holdover time testing will be conducted using samples representative of the manufacturers lowest recommended on-wing viscosity. Current methods for establishing holdover times in snow involve outdoor testing, which has been the source of industry concern for some time. It is recommended that a snowmaking device in development need to be evaluated for the future conduct of snow holdover time tests in controlled conditions. The study of fluid buffers was also continued in 97/98 and identified several industry concerns which will be addressed in further research. The adherence of contaminated fluid to aircraft wings was also evaluated in a series of simulated takeoff runs without aircraft rotation. Further research in these areas is needed.

2. PROGRAM OBJECTIVE (MCR 16)

Take an active and participatory role to advance aircraft ground de-icing/anti-icing technology. Develop international standards, guidance material for remote and runway-end de-icing facilities, and more reliable methods of predicting de-icing/anti- icing holdover times.

3. PROGRAM SUB-OBJECTIVES

3.1. Develop reliable holdover time (HOT) guideline material based on test information for a wide range of winter weather operating conditions.

3.2. Substantiate the guideline values in the existing holdover time (HOT) tables for fluids that have been qualified as acceptable on the basis of their impact on aircraft take-off performance.

3.3. Perform tests to establish relationships between laboratory testing and real world experience in protecting aircraft surfaces.

3.4. Support development of improved approaches to protecting aircraft surfaces from winter precipitation.

4. PROJECT OBJECTIVES

4.1. Develop holdover time data for all newly qualified de/anti-icing fluids.
4.2. Develop holdover time data for Type IV fluids using lowest qualifying viscosity samples.
4.3. Develop supplementary data for a reduced buffer 'de-icing only' Table.
4.4. Determine whether recycled, recovered fluid can be used as a 'De-icing only' fluid.
4.5. Determine whether the extreme precipitation rates used for laboratory testing of de/anti-icing fluids are in fact encountered in practice.
4.6. Obtain equipment for laboratory production of artificial snow which most closely reproduces natural snow.
4.7. Assess the limiting conditions of wind, precipitation and temperature under which water can be used as the first step of a two-step de-icing procedure.
4.8. Determine the patterns of frost formation and of fluid failure initiation and progression on the wings of high-wing turbo-prop and jet commuter aircraft.
4.9. Assess the practicality of using vehicle-mounted remote contamination detection sensors for pre-flight (end-of-runway) inspection.
4.10. Provide base data on the capabilities of remote sensors.
4.11. Provide pilots with reference data for the identification of fluid failure. Quantify pilot capabilities to identify fluid failure
4.12. Provide support services for the conduct of tests to determine under what conditions contaminated fluid adheres to aircraft lifting surfaces.
4.13. Assess whether pre-warming fuel at time of re-fuelling will help to eliminate the 'cold soaked' wing problem.
4.14. Develop a low-cost test wing which can be used in the laboratory in lieu of field testing full scale aircraft.
4.15. Establish the safe limits for de-icing truck operation when de-icing aircraft with the engines running.
4.16. Provide general support services.
4.17. Disseminate test findings

5. DETAILED STATEMENT OF WORK

5.1. General

5.1.1. Planning and Control

Develop a detailed work plan, activity schedule, cash flow projection, project management control and documentation procedures (as specified in Section 9,"Project Control") within three weeks of effective commencement date, confirming task priorities, suggesting hardware and software suppliers, broadly identifying data needs and defining the roles of subcontractors, and submit to TDC for review and approval.

5.1.2. Safety and Security

Particular consideration will be given to safety in and around aircraft on the airport and deicing sites In the event of conflict between access for data gathering to obtain required test results and safety considerations, safety shall always govern.

5.2. Holdover Time Testing and Evaluation of De/Anti-icing Fluids

5.2.1. Newly Certified Fluids

Conduct flat plate tests under conditions of natural snow and artificial precipitation to record the holdover times, and to develop individual Holdover Time Tables based on samples of newly certified or re-certified fluids supplied by Fluid Manufacturers under as wide a range of temperature, precipitation rate, precipitation type, and wind conditions as can be experienced. Anticipate tests for one new fluid. Snow tests shall be conducted outdoors, and ZD, ZR-, Zfog, and CSW tests will be performed in the laboratory. All testing shall be performed using the methodology developed in the conduct of similar tests for Transport Canada in past years.

5.2.2. Low Viscosity Type IV Anti-icing Fluids

Fluid holdover time testing of Type IV fluids will be conducted using procedures established during past test seasons but using fluid with the lowest operational use viscosity.

5.2.2.1. Flat Plate Tests for New Type IV Fluids

Conduct flat plate tests under conditions of natural snow and artificial precipitation to record the holdover times, and develop individual Holdover Time Tables based on samples of new Type IV fluids supplied by Fluid Manufacturers under as wide a range of temperature, precipitation rate, precipitation type, and wind conditions as can be experienced. Anticipate for four new fluids using samples with one viscosity. Snow tests shall be conducted outdoors, and ZD, ZR-, Zfog, and CSW tests shall be performed in the laboratory using methodology applied in past years.

5.2.2.2. Effect on Holdover Time of Viscosity

Conduct tests aimed at determining the effect of fluid viscosity on holdover time. Tests shall be conducted in light freezing rain and freezing drizzle conditions at various temperatures in the National Research council (NRC) Climatic Environment facility (CEF) using low and high viscosity samples representing production limits of three anti-icing fluids: a propylene, an ethylene and the Fluid X (which will become the benchmark for laboratory based HOT testing).

Anticipate a total of approximately 100 tests to be conducted under ZR- and ZD at -3 and -10 Celsius at low and high rates.

5.2.3. Recycled Fluids as Type I Fluids

5.2.3.1. Holdover Times

A complete set of holdover time tests shall be conducted using two fluid test samples of recovered glycol based freezing point depressant fluid which have been recycled and exhibit nominal conformance to Type I de-icing fluid performance characteristics. The objective of this series of tests is to establish a sound base of data sufficient to establish valid holdover time tables for these fluids.

5.2.3.2. Compatibility with Type IV Fluids

Fluid compatibilty trials shall be conducted using various combinations of the recycled fluids and commercial Type IV fluids. Determine how the Inland fluids perform when used in conjunction with a Type IV fluid overspray.

5.3. Supplementary Data for Deicing Only Table

Evaluate the test conditions used in establishing the deicing only table by undertaking the following test series at sub zero temperatures but with no precipitation.

5.3.1. Establish Quantity of Fluid for Field Tests.

Conduct a series of comparative laboratory tests with 0.5, 0.25 and 0.1 litre per plate. Consider the case of spraying for frost with a fan shape to cover a wide area with a small amount of fluid compared with a stream as used to remove snow or ice. Examine typical fluid quantities representing frost removal spray. Conduct some tests on aircraft piggybacking on other testing if feasible.

5.3.2. Establish Temperature of Fluid for Field Tests

Laboratory tests will be performed with fluids initial temperatures at the spray nozzle of 60°C, 50°C, and 40°C initial temperature.

Field tests on aircraft will be designed to measure the loss of fluid temperature and to measure fluid evaporation and enrichment during the air transport phase between spray nozzle and wing surfaces, for various distances and shapes of spray pattern (3 distances; 2 spray patterns).

5.3.2.1.

Examine the effect on the final freeze point of sprayed fluids on the wing, resulting from variations in the temperature of the fluid (60°C, 50°C, and 40°C).

5.3.2.2.

Examine the effect on wing heat and fluid evaporation of removing contaminant from the wing surface. Various degrees of ice depth shall be deposited using a hand-held rainmaker, including a very light coating to simulate frost. The amount of fluid sprayed shall be controlled by the operator, spraying until a clean surface results.

5.3.3. Perform tests at current buffer limit as baseline.

Perform a series of comparative tests using buffers at 3°C and 10°C to compare to the new data and the data collected last season with buffers at 0°C .

5.3.4. Simulate High Wind Conditions

Tests shall be performed using NRC fans producing winds up to 30 kph for comparison with the earlier series of tests with speeds up to 20 kph

5.3.5. High Relative Humidity

Perform a series of plate tests at 90% RH to compare results to those already gathered. Review the condition with weather services to determine typical RH values during deicing only conditions.

5.3.6. Cold Soaked Wings

Perform a series of tests on cold soak boxes to establish whether the natural buffer provided by evaporation would be sufficient to provide protection if the wing were in a cold-soaked condition, with wing temperature several degrees below OAT. These tests can be run in conjunction with high humidity tests when deposition of frost on cold soaked surfaces would normally be expected.

5.3.7. Effect of Snow Removal on Fluid Heat Input

Perform tests to establish whether removal of snow results in extesive amounts of heat being carried away and insufficient heat being transferred to the wing during deicing.

Expose flat plates to snowfall (either natural or as simulated by approved equipment) and protect snow catches of various thicknesses. Tests shall be run in an area protected from further snowfall. Fluid shall be applied with a hand sprayer, until the plate is cleaned, measuring the amount of fluid applied.

The final fluid concentration on the plate shall be measured. The heat lost in fluid run off shall be measured. Parallel tests will be conducted on bare surfaces.

A carefully calculated heat balance shall be determined for each experiment based on the temperatures of the applied fluid, the plate and the collected run-off material.

5.3.8. Effect of Composite Surfaces on Evaporation

Evaluate the effects of the use of composite materials in wings on the heat transfer from deicing fluid to the wing. Conduct a series of laboratory comparative tests on a several samples of composite surfaces.

Identify an appropriate aircraft having a wing surface composed of new technology composite material as well as aluminium, determining the thermal pathways connecting the composite surfaces to the main wing structure.

Conduct field tests on a sample aircraft.

5.3.9. Unpowered Flight Control Surfaces

Field trials will be conducted on DC9 aircraft to assess the impact of fluids of various buffers on the freedom of operation of the unpowered elevator control tabs to establish whether the natural buffer provided by evaporation would be sufficient to provide protection if the wing were in a cold-soaked condition, with wing temperature several degrees below OAT

5.3.10. Field Tests on Aircraft

Three overnight test sessions shall be planned for these tests. Tests shall be conducted on aircraft types including the McDonnell Douglas DC-9 and Canadair RJ, with a minimum of one night for each type. Testing on a third aircraft type would be useful to improve confidence and to confirm the universality of the results. Use an ice detector sensor system to provide a separate source of data.

5.3.11. Laboratory Tests

The number of proposed tests shall be controlled by limiting tests to the minimum number of ambient conditions that will support conclusions on the significance of the issues raised while maintaining a good level of confidence. As a minimum, this encompasses about 230 plate tests and would require about 8 days at the NRC CEF Facility or other suitable facility.

5.4. Flow of Contaminated Fluids from Wings during Takeoff

5.4.1. Requirement

Evaluate anti-icing fluids for their influence on adherence, in particular, propylene based Type IV fluids which were observed during fluid failure

A test plan shall be developed jointly with NRC.

Two days of testing at Mirabel Airport shall be planned.

Use an ice contamination sensor to assist in documenting contamination levels to provide valuable assistance in data gathering. A contingency allowance to fund sensor company participation shall be included.

Data collected during these trials shall include:

- type of fluid applied;
- record of contamination level prior to take off runs,;record of level of contamination following takeoff runs;
- observations, photography and video taping, and ice sensor records; and
- specifics on aircraft takeoff runs obtained from NRC personnel.

5.4.2. Conduct of Trials and Assembly of Results

Coordinate all test activities, initiating tests in conjunction with NRC test pilots based on forecast weather. Analyse results and document all findings in a final technical report and in presentation format.

5.5. Aircraft Full-Scale Tests

5.5.1. Purpose of Tests

Conduct full-scale aircraft tests:

- To generate data which can be used to assist pilots with visual identification of fluid failure;
- To generate data to be used to assess a pilot's field of view during adverse conditions of winter precipitation for selected aircraft; (See item 5.11)
- To compare the performance of de/anti-icing fluids on aircraft surfaces with the performance of de/anti-icing fluids on flat plates;
- To examine the pattern of failure using Type IV fluid brands not tested in the past; and
- To further investigate progression of failure on the two wings in crosswind conditions.

5.5.2. Planning and Coordination

Planning and preparation for tests including provision of facilities, personnel selection and training, and test scheduling shall be the same as provided to TDC in previous years

5.5.3. Testing

All tests and dry runs shall be performed using the methodology developed in the conduct of similar tests for Transport Canada in past years.

Test planning will be based on the following aircraft and facilities:

Aircraft	Airline	Test Locn.	Deicing Pad	Deicing Crew
Canadair RJ	Air Canada	Dorval	Central	Aéromag 2000
ATR42	Inter Canadian	Dorval	Central	Aéromag 2000

5.5.4. Test Measurements

Make the following measurements during the conduct of each test:

- Contaminated thickness histories at selected points on the wings. The selection of test points shall be made in cooperation with the Transportation Development Centre,
- Contamination histories at selected points on wings (selected in cooperation with the Transportation Development Centre),
- Location and time of first failure of fluids on the wings,
- Pattern and history of fluid failure progression,
- Time to failure of one third of the wing surface
- Concurrent measurement of time to failure of fluids on flat plates. The plates will be mounted on standard frames and on aircraft wings at agreed locations,
- Wing temperature distributions,
- Amount of fluid applied in each test run and fluid temperature,
- Meteorological conditions, and
- For crosswind tasks, effects of rate of accumulation on each wing.

In the event that there is no precipitation during full-scale tests, the opportunity shall be taken to make measurements of fluid thickness distributions on the wings. These measurements shall be repeated for a number of fluid applications to assess the uniformity of fluid application.

5.5.5. Pilot Observations

Contact airlines and arrange for pilots to be present during the tests to observe fluid failure and failure progression, and to record pilot observations from the cockpit and the cabin for later correlation with aircraft external observations.

5.5.6. Remote Sensor Records

Record the progression of fluid failure on the wing using RVSI and/or Cox remote contamination detection sensors if these sensors are made available.

5.6. Snowmaking Methods and Laboratory Testing for Holdover Times

5.6.1. Evaluation of Winter Weather Data

5.6.1.1. Snow Rates

Collect and evaluate snow weather data (precipitation rate/temperature data) during the winter to ascertain the suitability of the data ranges used to date for evaluation of holdover time limits.

Obtain current data from Environment Canada for three sites in Quebec: Rouyn, Pointe-au-père (Mont-Joli), and Ancienne Lorette (Quebec City), in addition to Dorval (Montreal).

5.6.1.2.Fog Deposition Rates

Devise a procedure and conduct fog deposition measurements outdoors on at least two occasions to determine the range of fog deposition rates which occur in natural conditions.

5.6.1.3. Frost Deposition Rates

Frost deposition rates shall be collected at various temperatures in natural conditions in order to determine a deposition range for this condition. Consideration shall be given to collecting deposition rates in cold temperatures (for example in Thompson, Manitoba). A total of five sessions shall be planned.

5.6.2. Snowmaking Methods

Acquire a version of the new snow generation system recently developed by the National Centre for Atmospheric Research (NCAR).

Evaluate the NCAR system for the future conduct of holdover time testing in simulated snow conditions. Tests shall be conducted in a small climatic chamber at Concordia University, PMG Technologies, or at NRC. Tests shall also be conducted with one Type IV fluid over a range of temperature and snowfall rates to compare the SAE holdover times for this fluid in natural and simulated conditions.

A further series of tests shall be performed with the system in order to assess the holdover time performance of the reference fluid (as described in the proposed SAE test procedures).

A total of 8 days of climatic chamber rental shall be planned for the conduct of the proposed tests.

5.7. Documentation of Appearance of Fluid Failure for Pilots

Current failure documentation deals largely with freezing drizzle and freezing rain conditions

5.7.1. Documentation of Failures

Finalise documentation of failure through limited further research as follows:

5.7.1.1.

provide similar documentation for fluids exposed to snow conditions, taking advantage of the availability of a snow making device for laboratory use;

5.7.1.2.

provide documentation for a propylene based Type IV fluid at typical delivered viscosity, for precipitation conditions tested previously, to determine characteristics at its operational limits and the nature and mechanisms of failure. Conduct selected comparison tests with a second fluid to test commonality of responses. Data from this activity will be cross-analysed with data from proposed research to examine the flow of similar fluids at different levels of contamination from aircraft wings during a simulated takeoff; and

5.7.1.3.

examine and document the appearance and nature of failure of propylene base fluids at cold temperatures (-10 C).

5.7.1.4.

Conduct tests at the National Research Council Climatic Environmental Facility based on last years' procedures, with enhancements as necessary and available. Snow documentation may be conducted in a different laboratory facility. Documentation under outdoor snow conditions will be conducted for comparison purposes to laboratory conditions.

5.7.2. Conduct of trials/assembly of results

Coordinate all test activities, scheduling tests with NRC CEF in conjunction with other test activities. Analyse results and document all findings, recommendations and conclusions in a final technical report and in presentation format. Provide timely updates of schedule revisions to TDC.

5.7.3. Pilot Observations

Contact airlines and arrange for pilots to be present during tests to observe fluid failure and failure progression. Record pilot observations for later correlation with aircraft external observations.

5.8. Feasibility of Performing Wing Inspections at End-of-runway

5.8.1. Requirement

Examine the feasibility of scanning aircraft wings with ice contamination sensors just prior to aircraft entering the departure runway using Dorval airport as an example scenario.

Explore ways of positioning sensors at agreed locations on an airport.

Composition and conduct of tests shall be adapted as information is gained on the practicality of this activity.

5.8.2. Planning

A Project Plan shall be prepared which will include:

a) activities to determine the parameters, operational issues and constraints related to the proposed process, and

b) a test plan for operational trials to examine the capabilities of the contamination sensors to determine the feasibility of their operational use.

The test plan for operational trials (three sessions) shall include:

- establishing test locations with airport authorities,
- establishing operational procedures with airport authorities,

- arranging equipment for scanning; vehicle, sensor installation and radios,
- collecting and coordinating information from the deicing activity at the deicing centre,
- test procedures with detailed responsibilities for all participants,
- control of the confidential data gathered on wing condition, and
- notification to all concerned in the project, including aircraft operators, that scanning activities will take place.

5.8.3. Coordination

Coordination all activites with authorities from Aéroports de Montréal and arrange support from Cox and/or RVSI

5.8.4. Field Trials

Conduct trials to further evaluate the feasibility of integrating such a process within current airport operations management, as well as to gather information on wing condition, just prior to takeoff, during deicing operations. These trials shall be based on the use of mobile equipment currently available. A "truthing" test pannel shall be present at each trial to demonstrate the validity of the wing readings on an ongoing basis

The trials shall be designed to address issues such as:

- equipment positioning versus current runway clearance limitations,
- time delay between inspection and start of take-off
- system capabilityto meet its design objectives in severe weather
- suitability of mobile equipment or fixed facility.
- need for rapid extension and retraction of sensor booms,
- airport support needed, e.g. snow clearance, provision of operating locations,
- accommodating scanner limitations for distance, light, angle of incidence.
- communications needed to support scanning operation,
- recording data from the sensors, and
- communicating results of the scanning to pilots and regulatory authorities.

5.8.5. Test Personnel and Participation

Initiate all tests based on suitable weather conditions. The individual test occasions shall be coordinated with Aéroports de Montréal and Aéromag 2000. Coordinate the provision of a suitable vehicle and the installation of an ice detection sensor. Monitor the test activity, ensuring the collection and protection of all scanning data, as well as the collection of data related to weather conditions and previous aircraft deicing activities. Ensure that the instrument providers deliver data and an objective measure of wing contamination based on scanner information in a timely and reproducible manner.

5.8.6. Study Results

Results from the feasibility study shall be presented in technical report format which shall include comments pertinent to long term implementation.

Results from the scanner tests shall be provided in technical report format and shall include analysis of wing contamination data cross-referred to the deicing history of individual aircraft scanned.

5.9. Ice Detection Sensor Certification Testing

5.9.1. Minimum Ice Thickness Detectable in Tactile Tests

Prepare procedures and conduct tests to establish human limits in identifying ice through tactile senses. These tests shall use the NRC or equivalent test facilities acceptable to TDC and a test setup equivalent to that planned for sensor certification. Several ice thicknesses and textures shall be tested to establish tactile sensing limiting thickness for smooth ice and for roughened ice.

The experiment shall involve sufficient participants and test conditions such as to provide reliable results usable in approving sensors to replace human tactile testing.

TDC shall assist in the experimental design

Tests shall be conducted with both contractor personnel and a selection of pilots as subjects.

A professional human factors scientist shall be used to establish testing parameters such as:

- what proportion of plates should be bare
- whether subjects should be blindfolded to eliminate visual cues.
- whether the same plate should be judged more than once
- how to ensure that subjects do not compare plates
- what should be the minimum time between plate touching

Results of the tests shall be analysed statistically to establish confidence limits for the findings

5.9.2. Field Tests for Sensor Distance and View Angle Limits

Develop a detailed test plan with a matrix of all test parameters, required coordination of equipment detailing the responsibilities of all participants.

Collect test data, including photo and video records of all tests.

The areas of ice contamination used for sensor evaluation shall be quantified by size, location and thickness. Angles of incidence, sensor heights and distances shall be verified independently. In concert with the sesor manufacturer, data from sensor readings and observer data shall be collated and analysed to reach conclusions on sensor limitations for distance and angle of incidence in various weather conditions.

5.10. Planning a Wing Deicing Test Site

Develop a plan for implementing a deicing test site, centred on an aircraft wing and supported by current fluid and rainmaking sprayers.
The plan shall include the acquisition of a surplus complete wing, from either a scrapped or an accidented moderate sized aircraft or an outboard section of a larger aircraft. The wing section should if possible include ailerons and leading edge slats
The design of the test site shall include a test area that could contain and recover sprayed fluids. Installation of the wing should entail a mounting designed to allow the wing to be rotated relative to current winds. The site must be secure yet allow ease of access and ability to install inexpensive solutions to control sprayed fluid.
Costs shall be estimated for the main elements of the development of a wing test bed site including:
wing purchase and delivery,
site lease and development, and
wing mount design and fabrication.

5.11. Evaluation of Hot (and Cold) Water Deicing

Investigate unheated and hot water deicing/defrosting, to determine under what meteorological conditions and temperatures these procedures are safe and practicable.
Unheated water deicing shall be evaluated at air temperatures above 1 degree C(34 degrees F).
Hot water deicing shall be evaluated at air temperatures below 1 degree C and include temperatures below −3 degrees C (27 degrees F).
These experiments shall establish how long it takes for the water to freeze on the surface under these conditions.
This is to be the first step of a two step procedure. From these data, a safe and practical lower limit shall be established considering the three-minute window required for second step anti-icing in the two-step deicing procedure.
Precipitation rates, as utilised in the generation of holdover time tables, shall be considered. Environmental chamber tests shall be correlated with outdoor aircraft tests. All laboratory test procedures and representative test results shall be recorded on videotape, including failure modes where applicable. The video shall depict a recommended full-scale aircraft hot water deicing procedure. A written report shall include the laboratory test results and a recommended aircraft unheated/hot water deicing procedure, including the limitations of precipitation, OAT and wind.

5.12. Evaluation of Warm Refuelling

Conduct a feasibility study of the suitability of refuelling with warm fuel to reduce susceptibility to "cold-soaked wing" icing, and to improve holdover times.

Coordinate activities to support testing the "warm fuel" concept using operational aircraft, including arranging;

- Participation of interested airlines, along with provision of aircraft for test purposes;
- Participation of local refueller;
- Arrangements with the equipment supplier (Polaris) to deliver the equipment to the selected airport along with the required technical support.

Testing will be conducted at Dorval on three occasions, one of which will include snow or freezing precipitation. Test aircraft selected should include a representation of both "wet" and "dry" wings if possible.

Wing surface temperatures of test wings will be monitored at several points over a period of time, to assess the influence thereon of warmed fuel. A reference case based on fuel boarded at the normal local temperature will be conducted.

5.13. Engine Air Velocity Distributions near Deicing Vehicles

Measure air velocity distributions in the vicinity of a de-icing truck when de-icing a large aircraft whose engines are running.

Tests shall be conducted during a period of no precipitation, either frost deicing or following snowfall, on two separate occasions at the Dorval International Airport deicing facility. Aircraft with engines mounted on the wing (e.g. B737) as well as rear engines mounted aircraft (e.g. DC-9 and RJ) will be sampled during live deicing operations, the precise type to be agreed by TDC. The tests shall be coordinated with Aéroport de Montréal and Aéromag 2000.

Wind velocity shall be measured from an Elephant-mu de-icing truck at locations recommended by TDC around the tail of the aircraft at different elevations and distances from the engines depending on the aircraft type, and the de-icing procedure followed by Aéromag 2000.

Photograph and video record the conduct of all tests.

5.14. Provision of Support Services

Provide support services to assist TDC with testing, the reduction of data and presentation of findings in the activites identified below which relate to the content of this work statement, but are not specifically included.

5.14.1.Re-Hydration

Conduct a series of exploratory trials on flat plates at the Dorval site or NRC to observe the behaviour of re-hydrated Type IV fluids and to help determine how re-hydration affects the flow- off characteristics of a Type IV fluid exposed to frost conditions.

5.14.2.Frost Tests on a Regional Jet

Conduct a series of tests to determine the roughness of frost deposition on the wings of a Regional Jet aircraft. Conduct tests on three overnight occasions.

5.14.3.Ice-Phobic Materials Evaluation

Conduct a series of tests on flat plates to determine the effects of ice-phobic materials on the film thickness and on holdover time of de/anti-icing fluids.

5.14.4.Evaluation of Infra-Red Thermometers

Evaluate use of infra-red technology as a method of determining accurate skin and fluid temperatures during operational conditions. Conduct tests in conjunction with full-scale and holdover time testing.

5.14.5.Frost Self-Elimination

Examine the self-elimination of frost on several test surfaces under variable weather conditions. Conduct test in conjunction with frost deposition trials on flat plates.

5.14.6.Environmental Impact Assessment

Assess the environmental issues related to the use of glycol-based products for aircraft de-icing purposes. Examine the waste fluid collection and disposal procedures for several deicing facilities in relation to current and future environmental legislation.

5.14.7.An Approach to Establish Wing Contamination

Document an approach to determining operational limits for levels of contamination on aircraft wings. This approach will include consideration of the location of contamination on the wings and the area contaminated. The levels of contamination on aircraft wings prior to takeoff as determined during the scanning trials prior to takeoff will be factored in.

The approach will discuss how the limits (when defined) could be used in software routines to enable sensor systems to provide Go/No-Go indications to the aircraft pilot and regulatory authorities.

5.14.8. Accident/incident Database Analysis

Provision of database manipulation and support aimed at establishing problem areas and their significance.

5.14.9.Other activities

Other activities, such as the evaluation of forced air technology, the evaluation of alternate (zero glycol) deicing methods, and the evaluation of frost removal equipment at gates, or others may emerge as issues during the course of the winter season.

APPENDIX B

TEST PROCEDURE

FLAT PLATE TESTS FOR SNOW

CM1514.001

EXPERIMENTAL PROGRAM
FOR DORVAL NATURAL PRECIPITATION FLAT PLATE TESTING
1998-99

APS AVIATION INC. APS

March 16, 1999
Version 2.0

EXPERIMENTAL PROGRAM
FOR DORVAL NATURAL PRECIPITATION FLAT PLATE TESTING
1998-99

This document provides the detailed procedures and equipment required for the conduct of natural precipitation flat plate tests at Dorval for the 1998-99 winter season.

1. OBJECTIVE

To conduct tests on standard flat plates to validate the current holdover time tables and develop holdover time tables for new fluids.

2. TEST REQUIREMENTS (PLAN)

Attachment B-I provides the test plan for fluid types to be tested at the Dorval test site located adjacent to the Atmospheric Environment Services. These tests shall be conducted during natural snow conditions.

3. EQUIPMENT

Test equipment required for the flat plate tests was determined from previous winters in association with the Society of Automotive Engineers (SAE) working group. This equipment is listed in Attachment B-II.

4. PERSONNEL (See Attachment B-III)

The following personnel are required for the conduct of tests. The responsibility for each tester is provided in Attachment B-III.

For one stand	For two stands
1 x Test site Leader/video	1 x Test site leader/video
1 x End condition tester	2 x End condition tester
1 x Meteo tester	2 x Meteo tester

5. PROCEDURE

The modified test procedure is included in Attachment B-II. This procedure was developed more than six years ago and was modified over the years to incorporate discussions at the SAE working group meetings. Attachment B-V contains a brief summary of the steps required to conduct a test.

6. DATA FORM

The data forms are included at the end of this document. One data form was developed for the end-condition tester (Table B-1) and one data form for the Meteo/video tester (Table B-2).

ATTACHMENT B-I

NATURAL SNOW PRECIPITATION TEST PLAN

NEW FLUIDS

Temperature Range	Type IV Neat	Type IV 75/25	Type IV 50/50	Type III
>0°C	YES	YES	YES	YES
0 to -3°C	YES	YES	YES	YES
-3 to -14°C	YES	YES	NO	YES
-14 to -25°C	YES	NO	NO	NO
below -25°C	YES	NO	NO	NO

File:g:\cm1380\procedur\nat_snow\TEST_PLN
At: All

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ATTACHMENT B-II
FLAT PLATE FIELD TEST EQUIPMENT AND PROCEDURE
1998-99 (Version 9.0)

This field test procedure has been developed by the SAE G-12 Holdover Time Subcommittee working group on aircraft ground de/anti-icing as part of an overall testing program that includes laboratory tests, field tests and full-scale aircraft tests, which is aimed at substantiating the holdover time table entries for freezing point depressant fluids known as de/anti-icing fluids.

1. SCOPE

This procedure describes the equipment and generalized steps to follow in order to standardize the method to be used to establish the time period for which freezing point depressant fluids provide protection to test panels during inclement weather such as freezing rain or snow.

2. EQUIPMENT

Environment Canada's READAC (Automated Weather Station) is located within 50 metres of the Dorval test stands. Data from this station will be acquired on a one minute basis. Temperature, total precipitation, visibility, wind speed and direction are among a few of the parameters measured.

2.1 Rain/Snow Gauge

The following equipment or equivalent are recommended:

2.1.1 Plate Pan (see Figure B-1)

A plate pan, placed at a 10° inclination on the test stand will be used to collect and weigh snow. The procedure for the collection of precipitation rates using this method is described in Attachment B-VII. A schematic of the plate pan is provided in Figure B-1.

Note: When this method is used the bottom and sides of the pan MUST BE WETTED (before each pre-test weighing) with Type IV anti-icing fluid to prevent blowing snow from escaping the pan. The plate pans should be carefully rotated every 5 minutes to prevent accumulating snow from blowing away. The time of rotation should be reduced to 2 minutes during heavy precipitation or high wind conditions.

2.1.2 Tipping Bucket

2.1.2.1 ETI snow gauge

Electronic simulation of a tipping bucket with a 0.25 mm (0.01") accuracy. The instrument is not heated (anti freeze used to melt precipitation).

2.2 Temperature Gauge for Panels (Optional)

T or K Type thermocouple thermometer capable of measuring outside air and panel temperatures to an accuracy of 0.5°C (1°F) over the range +10 to -30°C (+50 to -20°F). This gauge is optional and should be used to verify that the panel temperatures are cold-soaked to the outside air temperature.

2.3 Test Stand

A typical test stand is illustrated in Figure B-1A; it may be altered to suit the location and facilities, but the angle for the panels, their arrangement and markings must all conform to Figures B-1A and B-2. There shall be no flanges or obstructions close to the edges of the panels that could interfere with the airflow over the panels.

2.4 Test Panels

2.4.1 Material and Dimensions

Alclad Aluminum 2024-T6 or 5052-H32 polished standard roll mill finish 30x50x0.32 cm (12x20x11/6"), for a working area of 25x40 cm (10x16"). Thicker aluminum stock may be needed when an instrument is mounted on the plate.

2.4.2 Markings

Each panel shall be marked as shown in Figure 2 with lines at 2.5 and 15 cm (1 and 6") from the panel top edge, with 15 crosshair points and with vertical lines 2.5 cm (1") from each side; this marks off a working area of 25x45 cm (10x18") on each panel. All marks shall be made using a 0.3 cm (1/8") thick black marker or silk screen process, which does not come off with application of the test fluids or any of the cleaning agents. Re-marking of the plates will be required as the markings fade because of the cleaning actions.

2.4.3 Attachment

For attachment to the test stand, at least four holes shall be made, spaced along the two sides of each panel; the holes shall be within 2 cm (0.8") from the panel edge.

2.5 Fluid Application

The fluid should be poured onto the plates from a manageable container, until the entire test section surface is saturated and a consistent fluid thickness over the entire plate surface is obtained. Up to two litres of fluid may be applied to each panel. For indoor tests at the National Research Council, about 1 litre of fluid per panel is sufficient.

2.6 Film Thickness Gauge

Film thickness at the 15 cm (6") line can be evaluated (this is optional). Painter's wet paint film thickness gauge. 1-08 mil gauge or equivalent is available from Paul N. Gardner Company Inc., Pompano Beach, Florida.

2.7 Video recording (optional)

Tests may also be recorded with a hand-held video camera, in particular at the start of the test and when failures are being called. Care must be taken that the camera and any lighting do not interfere with the airflow or ambient temperatures.

2.8 Anemometer

Wind Minder Anemometer Model 2615 or equivalent. Available from Qualimetrics Inc., Princeton, New Jersey. To be mounted at 3 metres (10'). (For wind data and calibration sources, see TP12896E and TP12654E)

2.9 Wind Vane

Model 2020 Qualimetrics or equivalent. To be mounted at 3 metres (10'). (For wind data and calibration sources, see TP12896E and TP12654E)

2.10 Relative Humidity Meter

Relative humidity will be provided by READAC on a minute-by-minute basis.

2.11 Ice Detection Sensors

Where feasible surface or remotely mounted ice detection sensors should be used during the tests. Attachment IV provides a description of the sensor equipment and sensor procedures.

2.12 Addition Equipment

- Squeegee/scraper
- Extension power cords
- Flood lights
- Watches/stopwatches

3. DE/ANTI-ICING FLUIDS

3.1 Test Fluids

Only fluids that have been certified will be included in tests. Fluid suppliers shall submit to the test coordinating organization proof of certification for the fluids they provide.

3.2 Certification

Type IV fluids shall be sheared by each manufacturer to a viscosity level which is representative of the manufacturer's lowest recommended on-wing viscosity.

Each manufacturer shall provide samples and a certificate of compliance showing the viscosity of their test sample of fluid before and after the Shear Stabile Test. Test verifications of each fluid may be made at the Université du Québec à Chicoutimi.

3.3 Dye

Fluids should be supplied for certification and for testing in the form to be used on aircraft.

4. PROCEDURE

Attachment B-V contains a summary of the major steps required for the conduct of flat plate tests. This should be mounted on the wall in the trailer at the site.

4.1 Start-up and Close-up

Attachment B-V provides a reference to enable testers to start the equipment at the beginning of a test session, and also provides reference on what should be closed at the end of a session.

4.2 Set-up

4.2.1 Panel Test Stand

If there is any wind, orient the test stand so that the test panels are facing into the wind direction at the beginning of the test and the wind is blowing up the panels,

i.e.---->   /
wind   panel

If the wind shifts during the test do not move the stand; simply note it on the data sheet.

4.2.2 Tipping Bucket Precipitation Gauge

Place the precipitation gauge as close as possible to the test stand. Ensure that the interior level is used to indicate that the gauge is level. Ensure that the gauge is not shadowed by an object which would interfere with the collection of precipitation. If there is drifting snow it may be necessary to raise the snow gauge above the drift level but no higher than the test panel. The snow gauge measurements should be started as early as feasible and continue throughout the duration of all tests to provide a continuous record of precipitation.

4.2.3 Plate Pan Method

Add 0.6cm (¼") anti-icing fluid (Type IV) to the bottom of the pan as well as wetting the inner sides of the pan. Weigh the wetted pan prior to testing to the nearest gram. Weigh the pan at 10-minute intervals over the course of the test (see Table 2). Replace the pans on the test stand as long as the duration of the last test panel. Do not remove the contents of the pan until the test is complete. Weigh again after test completion of each panel to determine the true water content reading of the precipitation.

When using plate pans to measure precipitation rate, two plate pans shall be used. Care must be taken to ensure that snow or ice does not fall into the pans when transporting them into the trailer.

4.3 Test Panel Preparation

4.3.1 Before the start of each day's testing, ensure the panels are clean.

4.3.2 Place the panels on the fixture and attach to the frame screws with flat bolts (wing nuts will make attaching and removal easier in poor weather).

4.3.3 Allow the panels to cool to outside air temperature.

4.4 Fluid Preparation and Application

4.4.1 Fluid Temperature

Except for Type I fluids, all fluids should be placed outside (cold-soaked to ambient temperature conditions) at the start of the test session.

4.4.2 Cleaning Panels

Before applying test fluid to a panel, squeegee the surface to remove any precipitation or moisture. Fluid being used for the test could be used to help remove snow or ice from the test panel.

4.4.3 Order of Application

Apply the fluid to the panels, commencing at the upper edge of the test panel and working downwards to the lower edge. Ensure complete coverage by applying the fluid in a flooding manner. Start with the top left panel U, then cover panel X in the second row with the same fluid, then flood the second test fluid on panel V followed by panel Y, etc. (see Figure B-1).

4.5 Holdover Time Testing

4.5.1 Commence recording the test until the test reaches the END CONDITION. See Section 5 for definition of end condition.

4.5.2 Record the elapsed time (holdover time) required for the fluid to achieve the test END CONDITION.

4.5.3 In heavy precipitation, continue the test until the precipitation reaches the bottom of the panel. Record the time for this event.

4.6 Video Recording (not performed routinely)

Video record test (if required) with a hand-held camera in the following sequences:

1) General outdoor condition prior to test (get good view of snow falling).
2) Video record the data forms.
3) Video record pouring. Ensure that name of fluids are captured, testers faces, your voice, name and stand # (ensure date and time are available and synchronized).
4) Record pans being weighed and brought out.
5) Record establishing shot of test stand (all the plates).
6) Record establishing shot of each plate, followed by a close-up of the plate (scan the plate slowly), then returning to wide shot of the plate. Repeat this with each plate in sequence, beginning from left to right, top to bottom. Always follow the same sequence. Ensure that each plate has a tag marked with the type of fluid used on the plate and that the plate itself is marked with its corresponding letter (X, Y, Z...). Record the clock/timer often.
7) For each failure, record an overview of the plates, followed by a wide shot of the plate, zooming in into a close-up of the failure. Return to the establishing shot at the end of the procedure. Repeat this procedure for each failure.
8) Ensure that the lighting is appropriate for video purposes.
9) Ensure that the video camera is in fact recording. At the end of a test, rewind a few seconds and check that the test was recorded.

4.7 Plate Pan Measurements

Measure the quantity (rate) of precipitation using at least two plate pans mounted on the test stand. Record these measurements on the Form (Table B-2) at the following times:

- At the start of the test;
- Every 10 minutes;
- When there is a significant change in the rate (intensity) for more than one minute;
- After failure of each panel (measure only once if two panels fail at almost the same time); and
- At the end of the test.

4.8 Meteorological Observations

Meteorological observations must be recorded at the same times as in Subsection 4.7, and when there are changes in the type and category of precipitation. Significant changes in wind speed and direction should also be noted.

4.8.1 Type of Precipitation

Note the type of precipitation (refer to Figure B-4 for the codes). This is a subjective determination. If two or three forms of precipitation co-exist, then note all of these.

4.8.2 Classification of Precipitation

While many different classifications are available, a simple classification of ten forms of solid precipitation is shown in Figure B-3. Use of black velvet to collect the snow and inspect it, will facilitate the identification.

4.8.3 Determination of Wet or Dry Snow

While this is usually temperature and humidity level dependant, determination of wet or dry snow could be determined by collecting snow in a dry plate pan on a stand not being used. If in the course of a test, the snow in the pan can be combined and formed into a *snow-ball*, then this will be identified as wet snow. If the snow does not form into a *snow-ball* or if the snow does not even accumulate, then this is considered dry snow. Note that the time to form a *snow-ball*, when collecting with gloves, should be less then five seconds. One other method to determine whether the snow is wet or dry would be to measure the depth of the snow in the pan and compare it to the liquid equivalent depth. If the ratio is >10, then it would be dry snow.

4.8.4 Temperature and Wind Measurements

These are to be recorded from the computer monitor at the site at the start of the test. Readac information will also be used for data analysis.

4.9 Video Organization

The video equipment cassettes should be marked sequentially for the panning camera and the Hi 8 cameras. These numbers should be recorded on the data form at the time of testing. When these are full, then they should be marked as full.

5. END CONDITION

The plate failure time is that time required for the end conditions to be achieved. This occurs when the accumulating precipitation fails to be absorbed at any five of the crosshair marks on the panels or when 1/3 of the test panel is covered with accumulating precipitation.

A crosshair is considered failed if:

- There is a visible accumulation of snow (not slush, but white snow) on the fluid at the crosshair when viewed from the front (i.e. perpendicular to the plate). You are looking for an indication that the fluid can no longer accommodate or absorb the precipitation at this point.

OR

- When precipitation or frosting produces a *loss of gloss* (i.e. a dulling of the surface reflectivity) or a change in colour (dye) to grey or greyish appearance at any five crosshairs, or ice (or crusty snow) has formed on the crosshair (look for ice crystals). This condition is only applicable during freezing rain/drizzle, ice pellets, freezing fog or during a mixture of snow and freezing rain/drizzle and ice pellets.

As these determinations are subjective in nature, the following is **very important**:

- Whenever possible, have the same individual make the determination that a crosshair has failed.
- When making such a determination, ensure consistency in the criteria used to call the end of a test.
- Under light snow conditions or when the precipitation rate decreases, snow may sometimes build up on the fluid and then be absorbed later as the fluid accommodates (absorbs) it. If this occurs, record the first time snow builds up and note (in the comments sections) that there was an *un-failure* at a specific crosshair.

6. END OF TEST

Run test at least 10% longer than the time to reach the end condition on the last panel. This will allow the sensor traces to be longer for analysis. Once the test has ended, restart the testing procedure and continue as long as the weather conditions warrant.

7. REPORTING AND OBSERVATIONS

Calculate and record test data, observations and comments in the format of Tables B-1 and B-2. Each test must be conducted in duplicate. Detailed definitions and descriptions of meteorological phenomena are available in the Manual of Surface Weather Observation (MANOBS) - a copy is available at APS offices.

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ATTACHMENT B-III
PERSONNEL RESPONSIBILITY

Test Site Leader

- Call personnel to conduct tests.
- Ensure test site is safe, functional and operational at all times.
- Supervise site personnel \zduring the conduct of tests.
- Ensure site is opened and closed properly.
- Monitor weather forecasts on a daily basis.
- Report to project manager on site activities on daily basis.
- Review data forms upon completion of test for completeness and correctness (sign).
- Decide what fluids should be tested.
- Ensure results are reasonable.
- Ensure all clocks are synchronized at all times.
- Monitor weather forecasts during test period.
- Ensure fluids are available and verify fluids being used for test are correct.
- Ensure computers are all operational.
- Ensure electronic data is being collected for all tests.
- Ensure proper documentation of tapes, diskettes, cassettes.
- Verify test procedure is correct (eg. stand into wind).
- Ensure all materials are available (pens, paper, batteries, etc.)
- Ensure all equipment is on.
- Fill in end of testing checklist for every session (see Attachment B-VI).

End Condition Tester

- Monitor the progression of failures on the plates.
- Record end condition times for each crosshair.
- Communicate to video operator the end condition times.
- Apply fluids onto test panels.
- Complete and sign Data Form (Table B-1).
- Prepare fluids for each test.

Meteo Tester

- Record meteo for both stands
- Rotate and measure plate pan weights.
- Squeegee plates prior the fluid application.
- Complete and sign Data Form (Table B-2).
- Assist end condition tester when failure times occur quickly.
- Place stop-watch and start stop-watch on test stand.

Video Tester

- Sign and fill in cassette #'s, etc. in data form (Table B-2)
- Video all tests (see procedure)
- Verify all equipment is on.
- Document and mark all cassettes used for all electronic equipment.
- Ensure camera batteries are recharged and available.
- Ensure lighting is appropriate.
- Video fluid application (capture fluid name on container).

ATTACHMENT B-IV

ICE SENSORS SYSTEM MANAGEMENT AND PROCEDURES

(The RVSI sensor, described in this procedure, is no longer in use. A sensor from Spar/Cox may also be provided during the Winter 98-99 test season.)

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ATTACHMENT B-V
SUMMARY OF STEPS TO CONDUCT TESTS

The following are the major steps required to conduct flat plate tests at Dorval.

Upon Entering Trailer

1) Turn on lights (outside and inside) and sign-in.
2) Determine tests to be conducted and fluids (Type III, IV to be placed outdoors).
3) Remove snow and clear access to stands.
4) Turn on C/FIMS computers.
5) Synchronize all clocks on all equipment in 4) and stop watches.
6) Start MET equipment data collection file.

For Each Test

1) Fill in general material on Tables B-1 and B-2, and prepare plate pans for start of test.
2) Place fluids by stand.
3) Ensure stand is into wind.
4) Start logging C/FIMS computers.
5) Record end condition times of all panels **(care to be taken for the 5th crosshair of each panel).**
6) Measure plate pan weights over the course of the test.
7) Video record start of test, progression of failures, and when the end condition (5 of 15 crosshairs) is being called on each panel.
8) Ensure forms are properly completed and signed.
9) Save C/FIMS data.
10) Start a new test.

To Close Trailer

1) Replenish fluids.
2) Log and document date, times, test #'s, etc. on all media
3) After major events (more than 10 tests), start new tapes for next occasion.
4) Place all media and test forms in large envelope for delivery to office.
5) Shut off the C/FIMS.
6) Close MET equipment data collection file.
7) Clean trailer and all garbage.
8) Ensure outdoor is left clean and presentable.
9) Close lights and sign-out.

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ATTACHMENT B-VI

CHECKLIST FOR SITE LEADER FOR END OF TESTING

	ENTER DATE														
ITEM															
ALL FLUIDS BROUGHT IN															
ALL FLUIDS REPLENISHED															
WASTE FLUIDS BROUGHT IN															
HANDHELD CAMERAS BROUGHT IN															
OUTDOOR AND STAND LIGHTS TURNED OFF															
C/FIMS COMPUTER TURNED OFF															
MET FILE CLOSED AND NEW FILE OPENED (MET COMPUTER KEPT ON)															
RVSI FILES COMPRESSED AND SAVED TO TAPE															
RVSI/Spar COMPUTERS TURNED OFF															
WRIST WATCHES HANDED IN															
ALL TEST MEDIA PROPERLY LABELED (HI 8, RVSI, C/FIMS)															
DATA FORMS CHECKED AND SIGNED															
ALL PERSONNEL SIGNED OUT															
TRAILER CLEANED UP															
TRAILER HEATER KEPT AT +17°C															
SITE LEADER INITIALS															

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ATTACHMENT B-VII
AMENDED PROCEDURE FOR THE COLLECTION OF PRECIPITATION

GENERAL

i) Two large timepieces should be installed in the trailer (one above the rate station, the other in the window adjacent to the door), to insure that accurate collection times are recorded. Both timepieces should be synchronized;

ii) Rates should be collected every 10 minutes in normal conditions and every 5 minutes in periods of high precipitation rates and high winds.

iii) In the event of error (dropped pan, lost fluid...), the error and time should be recorded on the data form. When fluid has been lost from the plate pans, pans should be reweighed prior to being placed on the test stand; and

iv) The start time of the rate collection period is recorded from the timepiece above the rate station prior to exiting the trailer. The time required to get from the rate station to outside the trailer door should also be recorded. This value (in sec.) should be included in the buffer column in Table B-2, and eventually deducted from the rate collection time. When entering the trailer following a rate collection period, record the time from the timepiece in the window near the door.

PROCEDURE

i) Ensure that both plate pans are marked (*upper* and *lower*);

ii) The bottom and sides of the pan must be wetted with Type IV anti-icing fluid to prevent blowing snow from escaping the pan;

iii) Tare the scale, then weigh the wetted pan to the nearest gram;

iv) Record the start time (hr/min/sec) from the timepiece located near the rate station before leaving the trailer to place the pans on the test stand, taking into consideration the time delay necessary to proceed outside from the rate station;

v) Ensure that the pans are placed in the proper location (upper and lower locations);

vi) Prior to removing the plate pans from the test stand for re-weighing, carefully wipe away any accumulated precipitation from the lips of the plate pans (ensure that the precipitation does not fall into the plate pan). Carefully remove the plate pans from the stand and proceed **immediately** to the trailer to re-weigh the pans. Do not rest the pans on top of one another while transporting. Once inside the trailer, rest the pans on a clean dry table surface;

viii) Upon entering the trailer, record the end time (hr/min/sec) from the timepiece in the window near the door;

ix) Carefully wipe the bottom, sides and lips of the pans prior to weighing;

x) Weigh the plate pan. Plate pans should be re-weighed until consistent measurements are obtained;

xi) Record the new weight (do not tare scale again), and bring the pans back outside;

xii) Start time from the timepiece near the rate station; and

xiii) Continue this procedure until the final plate on the test stand has failed.

FIGURE B-1
SCHEMATICS OF PLATE PAN AND TEST STAND

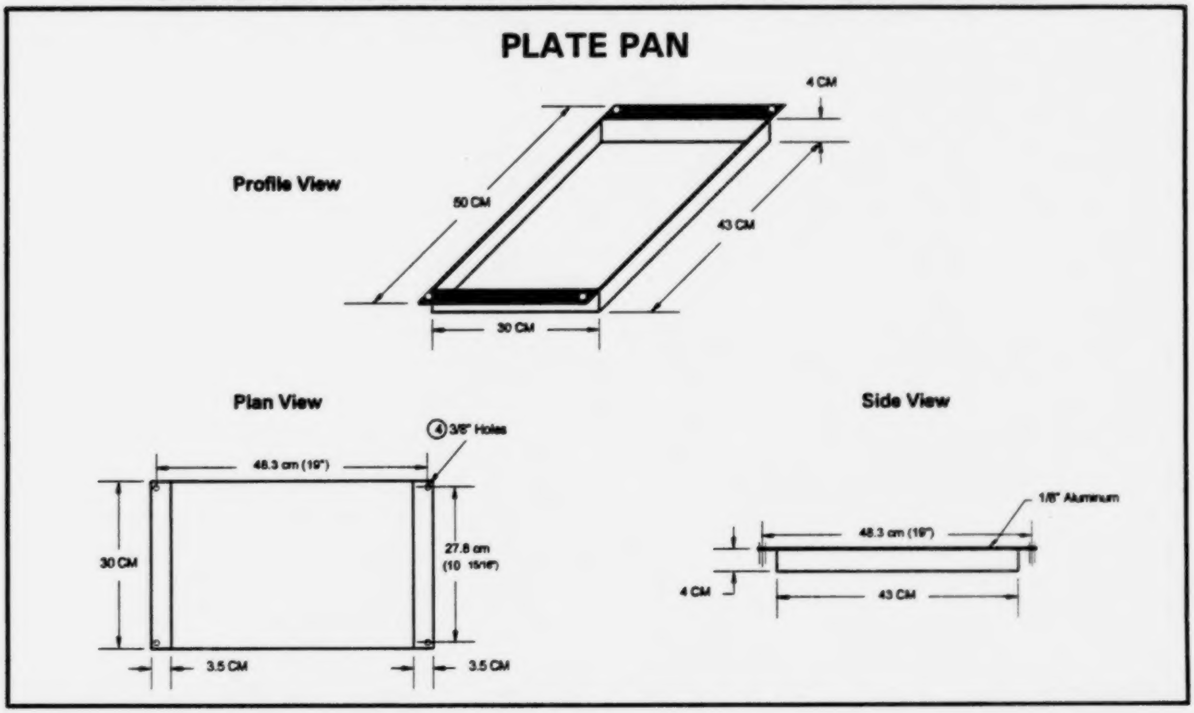
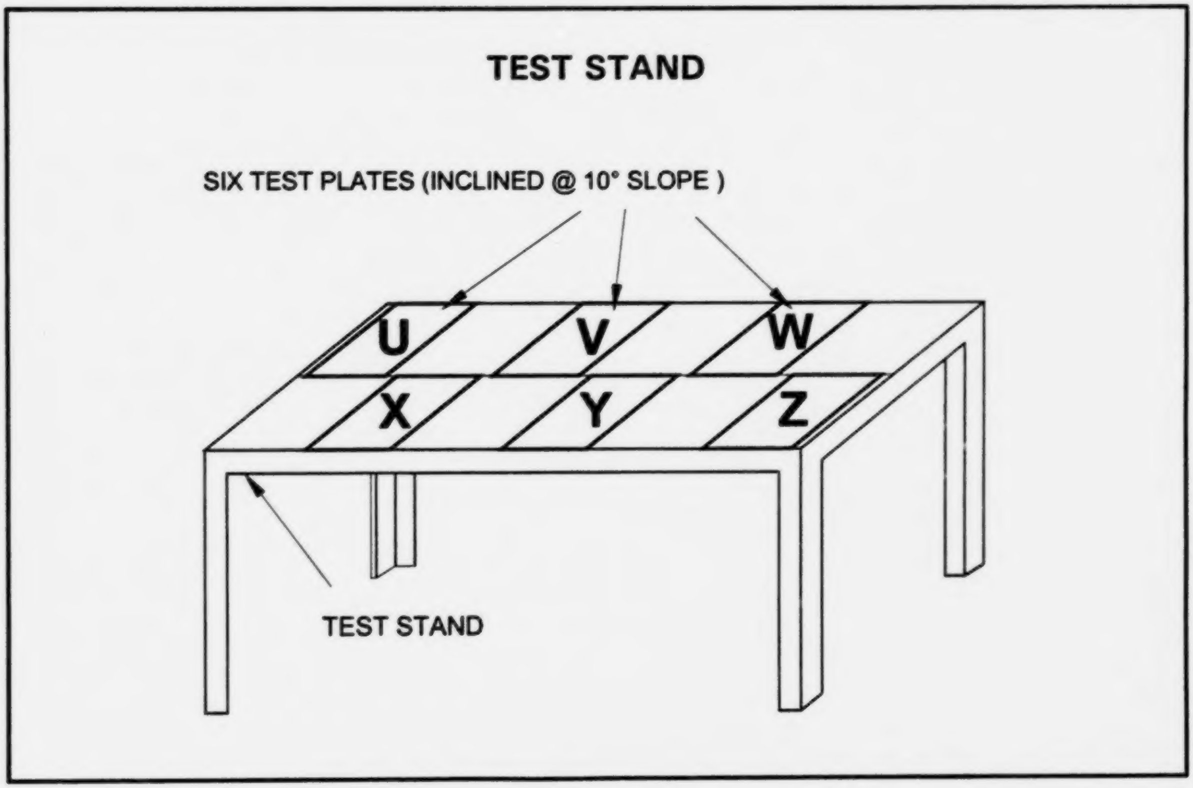


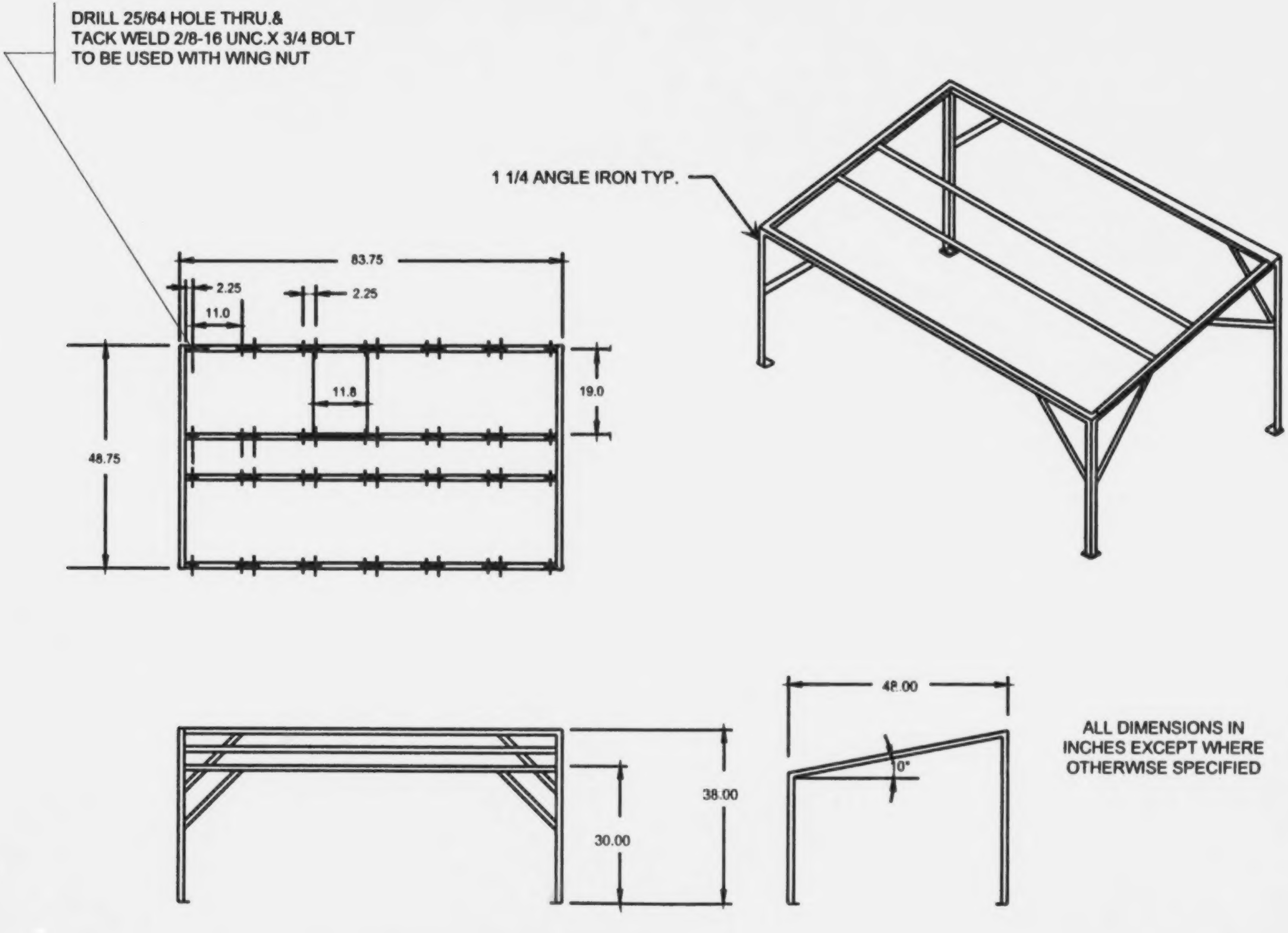
PLATE PAN
4 CM
Profile View
50 CM
43 CM
30 CM
Plan View
④ 3/8" Holes
48.3 cm (19")
30 CM
27.8 cm
(10 15/16")
3.5 CM
3.5 CM
Side View
1/8" Aluminum
48.3 cm (19")
4 CM
43 CM


TEST STAND
SIX TEST PLATES (INCLINED @ 10° SLOPE)
U
V
W
X
Y
Z
TEST STAND

bm3469\procedure\wet_snow\pan&stnd.drw

FIGURE B-1A

TEST STAND

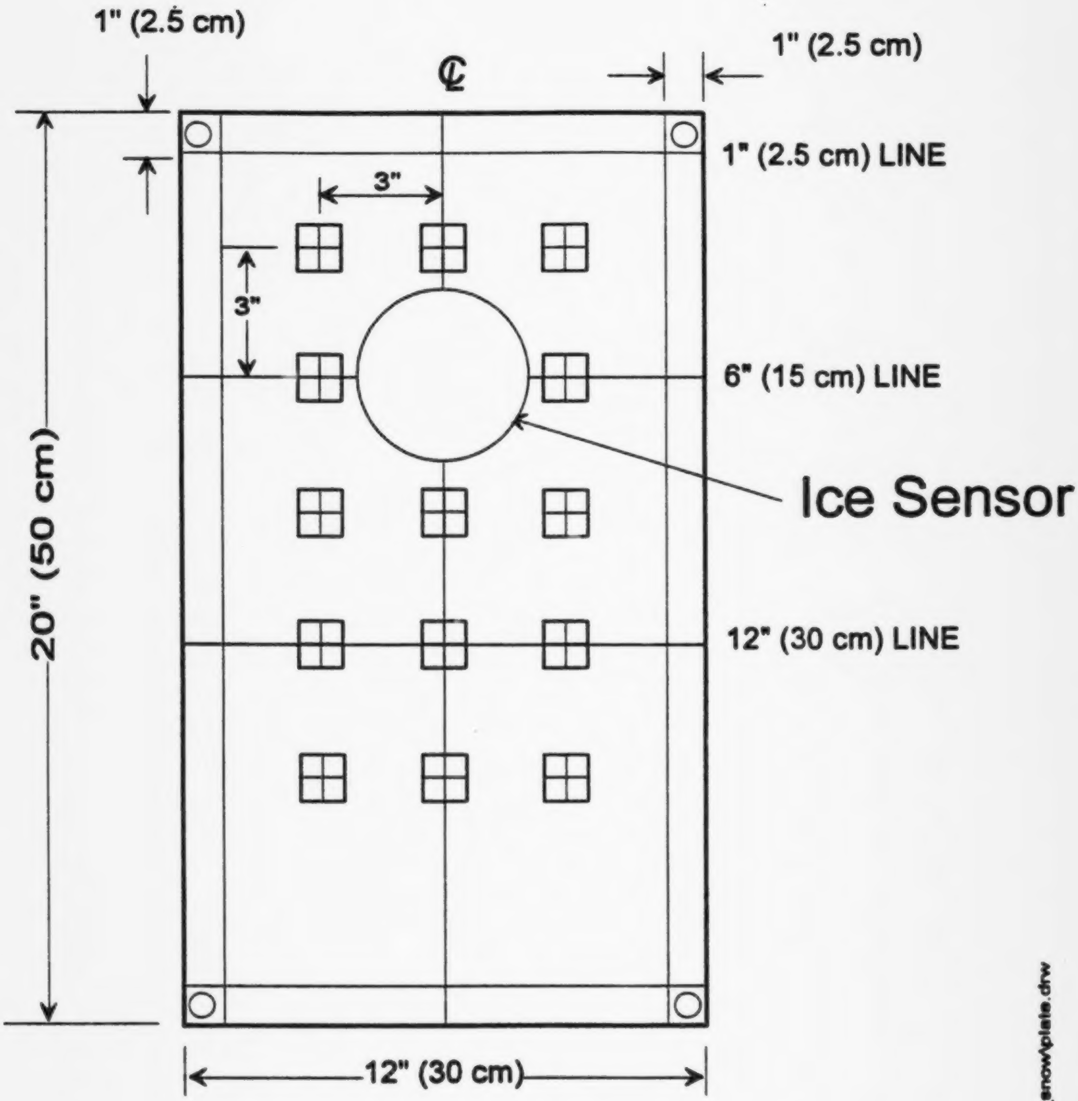

DRILL 25/64 HOLE THRU.&
TACK WELD 2/8-16 UNC.X 3/4 BOLT
TO BE USED WITH WING NUT
1 1/4 ANGLE IRON TYP.
83.75
2.25
2.25
11.0
11.8
19.0
48.75
48.00
0°
38.00
30.00

ALL DIMENSIONS IN
INCHES EXCEPT WHERE
OTHERWISE SPECIFIED

bm3469\procedure\nat_snowrack_r2.drw

FIGURE B-2

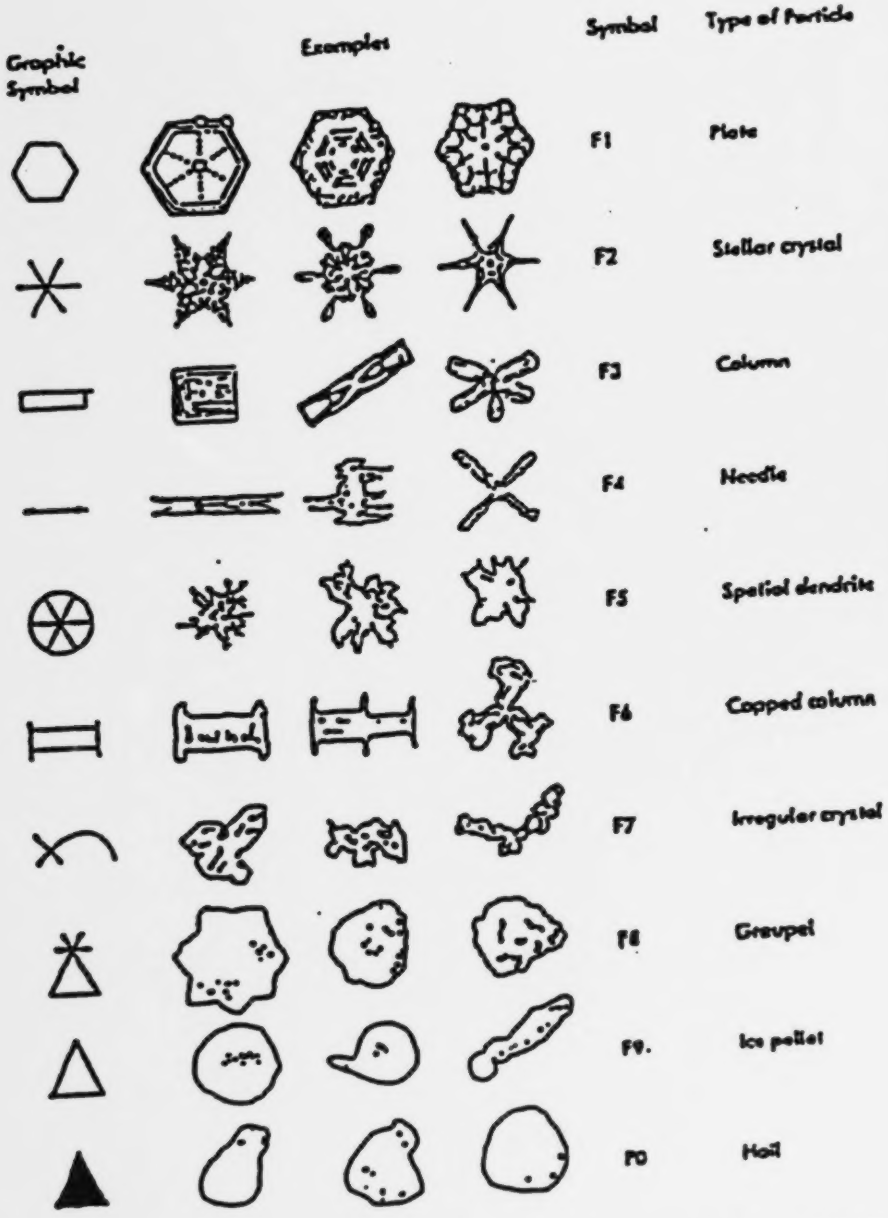
TYPICAL ICE SENSOR FLAT PLATE MARKINGS


1" (2.5 cm)
℄
1" (2.5 cm)
1" (2.5 cm) LINE
3"
3"
6" (15 cm) LINE
Ice Sensor
20" (50 cm)
12" (30 cm) LINE
12" (30 cm)

bm3469\procedur\net_snow\plate.drw

FIGURE B-3

INTERNATIONAL CLASSIFICATION FOR SOLID PRECIPITATION


Graphic Symbol
Examples
Symbol
Type of Particle
F1
Plate
F2
Stellar crystal
F3
Column
F4
Needle
F5
Spatial dendrite
F6
Capped column
F7
Irregular crystal
F8
Graupel
F9.
Ice pellet
F0
Hail

4. A pictorial summary of the International Snow Classification for solid precipitation. This classification applies to falling snow.

Source: *International Commission on Snow and Ice, 1951*

FIGURE B-4

WEATHER PHENOMENA AND SYMBOLS

General Category	Specific Phenomena	Symbol
Tornadoes and Thunderstorms	Tornado	Tornado
	Waterspout	Waterspout
	Funnel Cloud	Funnel Cloud
	Thunderstorm	T, T+
Precipitation	Rain	R--, R-, R, R+
	Rain Showers	RW--, RW-, RW, RW+
	Drizzle	L--, L-, L, L+
	Freezing Rain	ZR--, ZR-, ZR, ZR+
	Freezing Drizzle	ZL--, ZL-, ZL, ZL+
	Snow	S--, S-, S, S+
	Snow Grains	SG--, SG-, SG, SG+
	Ice Crystals	IC
	Ice Pellets	IP--, IP-, IP, IP+
	Ice Pellet Showers	IPW--, IPW-, IPW, IPW+
	Snow Showers	SW--, SW-, SW, SW+
	Snow Pellets	SP--, SP-, SP, SP+
	Hail	A--, A-, A, A+
Obstructions to ision (visibility miles or less)	Fog	F
	Ice Fog	IF
	Haze	H
	Smoke	K
	Blowing Snow	BS
	Blowing Sand	BN
	Blowing Dust	BD
	Dust Haze	D

TABLE B-1

END CONDITION DATA FORM

REMEMBER TO SYNCHRONIZE TIME WITH AES - USE REAL TIME

VERSION 5.0

Winter 97/98

LOCATION: **DATE:** **RUN # :** **STAND # :**

RVSI Series # : ____________________

CIRCLE SENSOR PLATE: u v w x y z

SENSOR NAME: ___ ___ ___ ___ ___ ___

DIRECTION OF STAND: ________ °

OTHER COMMENTS (Fluid Batch, etc):

____

____

____

____

____

____

____

____

	PRINT	SIGN
FAILURES CALLED BY :	____________________	____________________
HAND WRITTTEN BY :	____________________	____________________
TEST SITE LEADER :	____________________	____________________

***TIME (After Fluid Application) TO FAILURE FOR INDIVIDUAL CROSSHAIRS (hr:min)**

Time of Fluid Application: ________ hr:min (U & X) ________ hr:min (V & Y) ________ hr:min (W & Z)

	Plate U			Plate V			Plate W		
FLUID NAME									
B1 B2 B3									
C1 C2 C3									
D1 D2 D3									
E1 E2 E3									
F1 F2 F3									
TIME TO FIRST PLATE FAILURE WITHIN WORK AREA									
CALCULATED FAILURE TIME (MINUTES)									
BRIX AT FAILURE									

	Plate X			Plate Y			Plate Z		
FLUID NAME									
B1 B2 B3									
C1 C2 C3									
D1 D2 D3									
E1 E2 E3									
F1 F2 F3									
TIME TO FIRST PLATE FAILURE WITHIN WORK AREA									
CALCULATED FAILURE TIME (MINUTES)									
BRIX AT FAILURE									

METEO/PLATE PAN DATA FORM

VERSION 6.0   Winter 98/99

REMEMBER TO SYNCHRONIZE TIME WITH AES - USE REAL TIME

LOCATION: **DATE:**   **RUN # :**   **STAND # :**

HAND HELD VIDEO CASSETTE #:

PLATE PAN WEIGHT MEASUREMENTS *

PAN #	t TIME BEFORE (hh:mm:ss)	BUFFER TIME (Seconds)	t TIME AFTER (hh:mm:ss)	BUFFER TIME (Seconds)	w WEIGHT BEFORE (grams)	w WEIGHT AFTER (grams)	COMPUTE RATE (Δ w*4.7/Δt) (g/dm^2/h)

*measurements every 15 min. and at failure time of each test panel.

METEO OBSERVATIONS **

TIME (hr:min)	TYPE (Fig. 4) ZR, ZL,S, SG IP, IC, BS, SP	CLASSIF. (See Fig. 3)	If SNOW, WET or DRY

**observations at beginning, end, and every 10 min. intervals. Additional observations when there are significant changes.

TEMPERATURE AT START OF TEST ________ °C

WIND SPEED AT START OF TEST ________ kph

WIND DIRECTION AT START OF TEST ________ °

COMMENTS : ______________________________

____

____

____

	PRINT	SIGN
WRITTEN & PERFORMED BY :	________	________
VIDEO BY :	________	________
TEST SITE LEADER :	________	________

File bm3469\procedur\nat_snow\PFORMS-App B   At Meteo & Pan

APPENDIX C

TEST PROCEDURES – NRC APRIL

CM1514.001

DETAILED PLAN OF NRC COLD CHAMBER TESTING

Winter 1998-99

- Freezing Fog
- Freezing Drizzle and Light Freezing Rain
- Rain on a Cold-Soaked Surface

APS AVIATION INC.

April 1999
Version 4.0

DETAILED PLAN OF NATIONAL RESEARCH COUNCIL COLD CHAMBER TESTING

Winter 1998-99

This document provides the detailed procedures and equipment required for the conduct of simulated freezing fog, freezing drizzle/rain and rain on a cold-soaked surface holdover time tests. Procedures for supplemental tests, such as the evaluation of an artificial snowmaking machine and fluid thickness tests, are also provided in this document. These tests will be conducted at NRC's Climatic Engineering Facility (CEF) in Ottawa.

1. OBJECTIVES

The objective of the current holdover time test program is to establish holdover times for low viscosity Type IV fluids, new Type IV fluids, and Inland recycled fluids over the full range of HOT table conditions. Scheduling of the indoor tests will be coordinated with the NRC. Duration of tests will be 25 working days, including set-up time. Fluid failure will be determined by visual observation and supported by any ice detection instruments if these are made available.

The anticipated schedule of tests is provided in Attachment C-V.

2. PERSONNEL

An indication of the personnel required is provided in Attachment C-V.

Failure:	Determine test fluids and positioning of tests on stand. Determine failure times.
Rate 1/2/3:	Measure precipitation rates.
Fluids	Measure Brix at pour; measure temperature at pour; prepare fluids for next tests.
Mgr/Data Entry:	Manage tests; enter data (rates and failure times) as collected. Ensure C/FIMS is functional.
Fluid Application:	Ensure plates are clean; application of fluids.

3. PROCEDURES

- The procedures for indoor holdover time trials are shown in Attachment C- I;
- The rate procedure for holdover time trials is shown in Attachment C-VIII;
- The new rate procedure for holdover time testing, to be verified at NRC, appears in Attachment R;
- The test matrix for fluid thickness trials is shown in Attachment T;
- Attachment F contains procedures for frost tests in laboratory conditions;
- Freezing fog research procedures are shown in Attachment Z; and
- Procedures for microscope research appear in Attachment M.

4. TEST PLAN

Attachment C-V provides the test schedule for CEF tests while the detailed test plan is included in Attachment C-VI.

5. EQUIPMENT

Test equipment required for the flat plate tests was determined from previous winters in association with the Society of Automotive Engineers (SAE) working group on ground deicing. A description of some important equipment appears in Attachment C-I. The complete equipment list for CEF tests is shown in Attachment C-VII.

6. DATA FORMS

The data forms for tests conducted in simulated conditions are as follows:

- De/anti-icing data form for freezing precipitation, Attachment C-II;
- De/anti-icing data form for cold-soak box, Attachment C-IIA;
- Precipitation rate measurement, Attachment C-III;
- Detailed precipitation rate measurement form, Attachment C-IIIA;
- Continuous precipitation measurement form, Attachment C-IIIB; and
- Cold-soak precipitation rate measurement, Attachment C-IV.

ATTACHMENT C-I
INDOOR FLAT PLATE TEST EQUIPMENT AND PROCEDURE
1998-99

This indoor test procedure has been developed by the SAE G-12 Holdover Time Subcommittee working group on aircraft ground de/anti-icing as part of an overall testing program that includes laboratory tests, field tests and full-scale aircraft tests. The aim of this procedure is the development of holdover time table entries for freezing point depressant fluids known as de/anti-icing fluids.

1. SCOPE

This procedure describes the equipment and generalized steps to follow in order to standardize the method to be used to establish the time period for which freezing point depressant fluids provide protection to test panels during simulated winter conditions.

2. EQUIPMENT

The following equipment is required:

2.1 Plate Pans

Plate pans (27.7cm x 54cm), placed at a 10° inclination on the test stand, will be used to collect and weigh freezing precipitation. The procedure for the collection of precipitation rates using this method is described in Attachment VIII.

2.2 Temperature Gauge for Panels (change for 1999 tests)

Plate temperatures will be measured using thermocouples mounted directly underneath the test plate. All thermocouples are capable of measuring panel temperatures to an accuracy of 0.5°C (1°F) over the range +10 to -30°C (+50 to -20°F), and will be linked to an electronic data acquisition system.

2.3 Test Stand

A typical test stand is illustrated in Figure C-1; it may be altered to suit the location and facilities, but the angle for the panels, their arrangement and markings must all conform to Figure C-1. There shall be no flanges or obstructions close to the edges of the panels that could interfere with the airflow over the panels. Test panels should be positioned on the test stand at a 10° ± 0.2° angle from the horizontal.

2.4 Test Panels

2.4.1 Material and Dimensions

Test panels are made of Alclad Aluminum, 2024-T6 or 5052-H32, polished standard roll mill finish. The test panel dimensions are 300 x 500 x 3.2 mm, with a working area of 250 x 450 mm. Thicker aluminum stock may be needed when an instrument is mounted on the plate (CFIMS Sensor required 6.4 mm). Typical plate roughness used in APS Holdover time trials is 0.4 microns, measured parallel to the long axis of the plate.

2.4.2 Markings

Each panel shall be marked (as shown in Figure C-1) with lines at 25 and 150 mm from the panel top edge, with 15 crosshair points and with vertical lines 25 mm from each side; this marks off a working area of 250 x 450 mm on each panel. All marks shall be made using a 30 mm thick black marker or silk screen process, which does not come off with application of the test fluids or any of the cleaning agents. Re-marking of the plates will be required as the markings fade because of the cleaning actions.

2.4.3 Attachment of Test Panels

For attachment to the test stand, at least four holes shall be made, spaced along the two sides of each panel; the holes shall be within 20 mm (0.8") from the panel edge.

2.5 Fluid Application

The fluid should be poured onto the plates from a manageable container, until the entire test section surface is saturated and a consistent fluid thickness over the entire plate surface is obtained. For indoor tests at the National Research Council, about 1 litre of fluid per panel is sufficient.

2.6 Film Thickness Gauge

Film thickness at the 15 cm (6") line can be evaluated (this is optional). Painter's wet paint film thickness gauge. 1-08 mil gauge or equivalent is available from Paul N. Gardner Company Inc., Pompano Beach, Florida.

2.7 Video recording (optional)

Tests may also be recorded with a hand-held video camera, in particular at the start of the test and when failures are being called. Care must be taken that the camera and any lighting do not interfere with the airflow or ambient temperatures.

2.10 Relative Humidity Meter

Relative humidity in the test chamber will be recorded using a Vaisala RH Meter attached to an electronic data acquisition system.

2.11 Ice Detection Sensors

Where feasible, surface or remotely mounted ice detection sensors should be used during the tests.

2.12 Addition Equipment

- Squeegee/scraper
- Extension power cords
- Flood lights
- Watches/stopwatches

2.13 Test Chamber

Tests in simulated conditions will be conducted at the NRC, Climatic Engineering Facility in Ottawa. The chamber air temperature control is 0.5°C (+ standard deviation) based on the average air temperature measured at one-minute intervals. Temperature data is stored on the CEF data acquisition system. A minimum of three thermocouples are mounted in close proximity to the test stands and are monitored throughout the test set-up. The distance between nozzle and test plate is 6.5 to 6.7 meters, depending on the location of the plate on the test stand. The test chamber is equipped with artificial lighting arranged as such that it does not interfere with the precipitation nor with the air, fluid and plate temperatures

2.14 Spray Equipment

2.14.1 Characteristics of Precipitation Produced

The following is a point-form summary of the set of test conditions under which data for freezing drizzle, light freezing rain, rain on a cold-soaked surface, and freezing fog are collected:

- Freezing Drizzle:
  High precipitation rate: 12.7 g/dm²/hr;
  Droplet median volume diameter: 350 μm;
  Droplets produced with two # 23 hypodermic needles; and
  Air temperature: -3 and -10°C.

  Low Precipitation rate: 5 g/dm²/hr;
  Droplet median volume diameter: 250 μm;
  Droplets produced with two # 24 hypodermic needles; and
  Air temperature: -3 and -10°C.

- Light Freezing Rain:
  High precipitation rate: 25 g/dm²/hr;
  Droplet median volume diameter: 1 000 μm;
  Droplets produced with two # 20 hypodermic needles; and
  Air temperature: -3 and -10°C.

  Low precipitation rate: 12.7 g/dm²/hr;
  Droplet median volume diameter: 1 000 μm;
  Droplets produced with two # 20 hypodermic needles; and
  Air temperature: -3 and -10°C.

- Drizzle on Cold-Soaked Surface:
  Precipitation rate: 5 g/dm²/hr;
  Droplet median volume diameter: 250 μm;
  Droplets produced with two # 24 hypodermic needles; and
  Air temperature: +1°C.

- Moderate Rain on Cold-Soaked Surface:
  Precipitation rate: 76 g/dm²/hr;
  Droplet median volume diameter: 1 400 μm;
  Droplets produced with two # 17 hypodermic needles; and
  Air temperature: +1°C.

- Freezing Fog:
  Precipitation rate: 2 and 5 g/dm²/hr;
  Droplet median volume diameter: 30 μm; and
  Air temperature: -3°C, -14°C and -25°C.

2.14.2 Droplet Size Determination

The droplet size determination and distribution can be determined using the Dye Stain Method. The Dye Stain Method technique consists of dusting filter paper disks with a water activated, very finely divided, powder form of methylene blue dye. The prepared disks are manually positioned under precipitation for a fixed time in order to acquire a droplet size pattern. A calibration curve is then used to convert from the measured diameter of the droplets ton the pattern to the experimental median volume diameter. This method of droplet size determination has been used for several years (see Transport Canada Reports TP 12654E, TP 12896E, TP 13131E, TP 13318E).

2.14.3 Spray Distribution

The water spray shall be evenly distributed over the entire area of each test plate. Even distribution is verified by exposing either a clean test plate or sheet of paper briefly to the spray. Drop distribution on the plate or paper is visually evaluated. Uneven distribution requires that the spray equipment be adjusted (step size and spray head speed) until even distribution is achieved.

2.15 Calibration of Test Equipment

All temperature sensors, humidity sensors, electronic balances, anemometers, and timing devices shall be maintained in a known state of calibration. Our experience indicates that a one-year calibration interval is sufficient.

3. DE/ANTI-ICING FLUIDS

3.1 Test Fluids

Only fluids that have been certified will be included in tests. Fluid suppliers shall submit to the test coordinating organization proof of certification for the fluids they provide.

3.2 Certification

Type IV fluids shall be sheared by each manufacturer to a viscosity level which is representative of the manufacturer's lowest recommended on-wing viscosity. Each manufacturer shall provide samples and a certificate of compliance showing the viscosity of their test sample of fluid before and after shearing, as well as information pertaining to the freeze point and refractive index of the fluid and other fluid parameters as usually provided to the end users. Viscosity and refractive index verifications of each fluid shall be made by the test organization upon receipt of fluid from the manufacturer.

3.3 Fluid Dye

Fluids should be supplied for certification and for holdover time testing in the form to be used on aircraft.

4. PROCEDURE

4.1 Rate Procedure

The procedure for rate calculation is shown in Attachment C-VIII. A modified rate procedure will be tested this year at NRC and results presented. The new rate procedures are shown in Attachment R.

4.2 Test Panel Preparation

4.2.1

Before the start of each day's testing, ensure the panels are clean using the procedure outlined in 4.3.2.

4.2.2

Place the panels on the fixture and attach to the frame screws with flat bolts (wing nuts will make attaching and removal easier in poor weather).

4.2.3

Allow the panels to cool to chamber temperature. The temperature may be verified using the thermistors attached to each plate.

4.3 Fluid Preparation and Application

4.3.1 Fluid Temperature

Except for Type I fluids, all fluids should be cold-soaked to ambient temperature conditions prior to the start of the test session.

4.3.2 Cleaning Panels

The test panels must be clean of all contamination prior to the start of any test. This is accomplished by scrapping off contamination, or when a different type of fluid is to be tested, a hot water wash is used to remove traces of the previous fluid. Before applying test fluid to any test panel, apply a small quantity of the fluid being used for the test and spread it over the entire test surface.

Squeegee off any remaining fluid from the plate surface prior to the start of the test. Fluid for test is applied following procedure outlined in 4.3.3.

4.3.3 Fluid Application

Apply the fluids at ambient test temperature ±1.0°C to the panels, commencing at the upper edge of the test panel and working downwards to the lower edge. Ensure complete and consistent coverage by applying the fluid in a flooding manner (1 litre of fluid should suffice). Start time of the test begins immediately following completion of the fluid application.

4.4 Holdover Time Testing

4.4.1

Record the elapsed time (holdover time) required for the fluid to achieve the test END CONDITION. See Section 5 for definition of end condition.

4.5 Video Recording (not performed routinely)

Video record test (if required) with a hand-held camera in the following sequences:

1) General laboratory conditions prior to test.
2) Video record the data forms.
3) Video record pouring. Ensure that name of fluids are captured, testers faces, your voice, name and stand # (ensure date and time are available and synchronized).
4) Record pans being weighed and brought out.
5) Record establishing shot of test stand (all the plates).
6) Record establishing shot of each plate, followed by a close-up of the plate (scan the plate slowly), then returning to wide shot of the plate. Repeat this with each plate in sequence. Record the clock/timer often.
7) For each failure, record an overview of the plates, followed by a wide shot of the plate, zooming in into a close-up of the failure. Return to the establishing shot at the end of the procedure. Repeat this procedure for each failure.
8) Ensure that the lighting is appropriate for video purposes.
9) Ensure that the video camera is in fact recording. At the end of a test, rewind a few seconds and check that the test was recorded.

5. END CONDITION

The plate failure time is that time required for the end conditions to be achieved. This occurs when precipitation fails to be absorbed at any five of the crosshair marks on the panels or when 1/3 of the test panel is covered with accumulating precipitation.

A crosshair is considered failed if:

- There is a visible accumulation of snow (not slush, but white snow) on the fluid at the crosshair when viewed from the front (i.e. perpendicular to the plate). You are looking for an indication that the fluid can no longer accommodate or absorb the precipitation at this point.

OR

- When precipitation or frosting produces a loss of gloss (i.e. a dulling of the surface reflectivity) or a change in colour (dye) to grey or greyish appearance at any five crosshairs, or ice (or crusty snow) has formed on the crosshair (look for ice crystals). This condition is only applicable during freezing rain/drizzle, ice pellets, freezing fog or during a mixture of snow and freezing rain/drizzle and ice pellets.

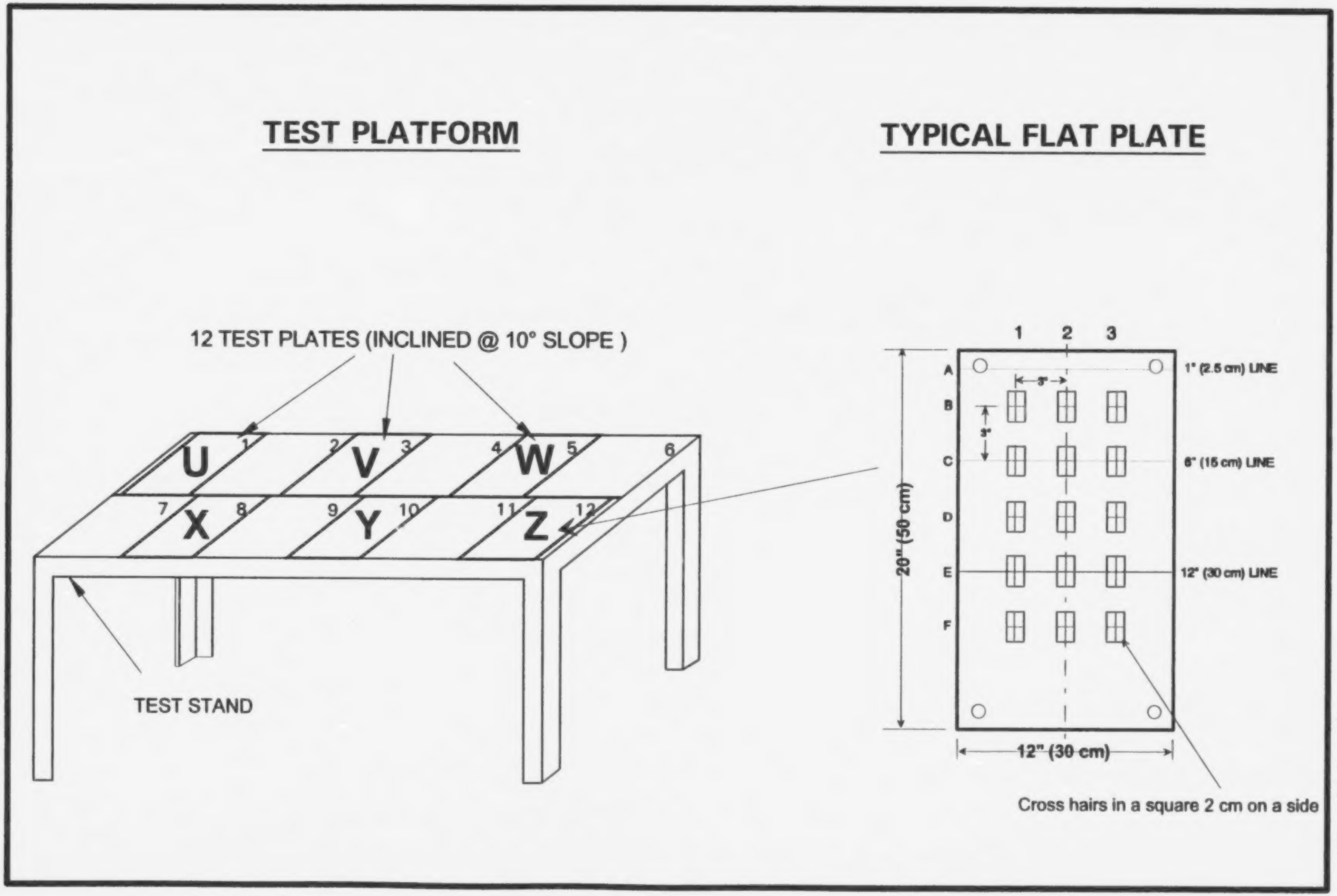
As these determinations are subjective in nature, the following is very important:

- Whenever possible, have the same individual make the determination that a crosshair has failed.

- When making such a determination, ensure consistency in the criteria used to call the end of a test.

FIGURE C-1

FLAT PLATE TEST SET-UP


TEST PLATFORM
12 TEST PLATES (INCLINED @ 10° SLOPE)
U
V
W
X
Y
Z
1
2
3
4
5
6
7
8
9
10
11
12
TEST STAND
TYPICAL FLAT PLATE
1
2
3
A
B
C
D
E
F
1" (2.5 cm) LINE
6" (15 cm) LINE
12" (30 cm) LINE
3"
3"
20" (50 cm)
12" (30 cm)
Cross hairs in a square 2 cm on a side

ATTACHMENT C-II

DE/ANTI-ICING DATA FORM FOR FREEZING PRECIPITATION

REMEMBER TO SYNCHRONIZE TIME VERSION 5.0 1997/98

LOCATION: CEF (Ottawa) **DATE:** **RUN NUMBER:** **STAND # :**

TIME TO FAILURE FOR INDIVIDUAL CROSSHAIRS (real time)

Time of Fluid Application:		______			______			______			______			______			______	
Initial Brix		______			______			______			______			______			______	
Initial Fluid Temperatrure		______			______			______			______			______			______	
		Plate 1			**Plate 2**			**Plate 3**			**Plate 4**			**Plate 5**			**Plate 6**	
FLUID NAME/BATCH																		
B1 B2 B3																		
C1 C2 C3																		
D1 D2 D3																		
E1 E2 E3																		
F1 F2 F3																		
TIME TO FIRST PLATE FAILURE WITHIN WORK AREA																		
FAILURE CALL	V. Difficult	Difficult.	Easy	V. Difficult	Difficult.	Easy	V. Difficult	Difficult.	Easy	V. Difficult	Difficult.	Easy	V. Difficult	Difficult.	Easy	V. Difficult	Difficult.	Easy
C/FIMS																		

Time of Fluid Application:		______			______			______			______			______			______	
Initial Brix		______			______			______			______			______			______	
Initial Fluid Temperatrure		______			______			______			______			______			______	
		Plate 7			**Plate 8**			**Plate 9**			**Plate 10**			**Plate 11**			**Plate 12**	
FLUID NAME/BATCH																		
B1 B2 B3																		
C1 C2 C3																		
D1 D2 D3																		
E1 E2 E3																		
F1 F2 F3																		
TIME TO FIRST PLATE FAILURE WITHIN WORK AREA																		
FAILURE CALL	V. Difficult	Difficult.	Easy	V. Difficult	Difficult.	Easy	V. Difficult	Difficult.	Easy	V. Difficult	Difficult.	Easy	V. Difficult	Difficult.	Easy	V. Difficult	Difficult.	Easy
C/FIMS																		

PRECIP: ZF , ZD , ZR-, MOD **AMBIENT TEMPERATURE:** ______ °C

COMMENTS: ______________________________

FAILURES CALLED BY : ______________________________

HAND WRITTTEN BY : ______________________________ **LEADER:** ______________

* To Compare to previous years of testing, subtract "Time of Fluid Application"

ATTACHMENT C-IIA

DE/ANTI-ICING DATA FORM FOR COLD SOAK BOX

REMEMBER TO SYNCHRONIZE TIME

LOCATION: CEF (Ottawa) **DATE:** **RUN NUMBER:** **STAND # :**

TIME TO FAILURE FOR INDIVIDUAL CROSSHAIRS (real time)

Time of Fluid Application															
Initial Brix															
Fluid Temperature															
Intial Box Temperature															
Enter Box Number	Box #			Box #			Box #			Box #			Box #		
FLUID NAME/BATCH															
B1 B2 B3															
C1 C2 C3															
D1 D2 D3															
E1 E2 E3															
F1 F2 F3															
TIME TO FIRST PLATE FAILURE WITHIN WORK AREA															
FAILURE CALL	V. Difficult	Difficult.	Easy	V. Difficult	Difficult.	Easy	V. Difficult	Difficult.	Easy	V. Difficult	Difficult.	Easy	V. Difficult	Difficult.	Easy
Final Box Temperature															

Time of Fluid Application															
Initial Brix															
Fluid Temperature															
Initial Box Temperature															
Enter Box Number	Box #			Box #			Box #			Box #			Box #		
FLUID NAME/BATCH															
B1 B2 B3															
C1 C2 C3															
D1 D2 D3															
E1 E2 E3															
F1 F2 F3															
TIME TO FIRST PLATE FAILURE WITHIN WORK AREA															
FAILURE CALL	V. Difficult	Difficult.	Easy	V. Difficult	Difficult.	Easy	V. Difficult	Difficult.	Easy	V. Difficult	Difficult.	Easy	V. Difficult	Difficult.	Easy
Final Box Temperature															

AMBIENT TEMPERATURE: ________ °C

COMMENTS: **FAILURES CALLED BY :** ________________

HAND WRITTTEN BY : ________________

* To Compare to previous years of testing, subtract "Time of Fluid Application".

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ATTACHMENT C-III

PRECIPITATION RATE MEASUREMENT AT CEF IN OTTAWA

Date:

Start Time:

Run # :

Stand:

Precip Type: (ZD, ZR-, FZF, S)

Needles used:

Flow Rate of Water:

Line Air Pressure:

Line Air Temperature:

Line Water Pressure:

Line Water Temperature:

Pan Location:

1	2	3	4	5	6
7	8	9	10	11	12

Collection Pan:

Pan #	Area of Pan (dm²)	Location	Weight of Pan (g)		Collection Time (hr:mm:ss)		Rate
			Before	After	Start	End	
1	14.56	1					
2	14.56	2					
3	14.56	3					
4	14.56	4					
5	14.56	5					
6	14.56	6					
7	14.56	7					
8	14.56	8					
9	14.56	9					
10	14.56	10					
11	14.56	11					
12	14.56	12					
13	14.56	13					
14	14.56	14					
15	14.56	15					
16	14.56	16					

Comments:

Handwritten by:

Measured by:

Precipitation Rate = $\Delta g/\text{area}\ (dm^2)/hr$

ATTACHMENT C-IIIA
DETAILED PRECIPITATION RATE MEASUREMENT AT CEF IN OTTAWA

PLATE

1	2
3	4

Date: ____________________

Start Time: ____________________

Run # : ____________________

Stand: ____________________

Precip Type: ____________________ (ZD, ZR-)

Pan Location (Circle):

1	2	3	4	5	6
7	8	9	10	11	12

Collection Pan:

Pan/ #	Area of Pan (dm²)	Weight of Pan (g)		Collection Time (hr:mm:ss)		Rate
		Before	After	Start	End	
1						
2						
3						
4						

Comments: ____________________

Handwritten by: ____________________

Measured by: ____________________

Precipitation Rate = Δg/area (dm^2)/hr

ATTACHMENT C-IIIB
CONTINUOUS PRECIPITATION RATE MEASUREMENT AT CEF IN OTTAWA

Date:

Start Time:

Run # :

Stand:

Precip Type: (ZD, ZR-, FZF, S, CS)

Pan Location:

1	2	3	4	5	6
7	8	9	10	11	12

Collection Pan:

Pan #	Area of Pan (dm²)	Location	Weight of Pan (g)		Collection Time (hr:mm:ss)		Rate
			Before	After	Start	End	
1	14.56						
2							
1							
2							
1							
2							
1							
2							
1							
2							
1							
2							
1							
2							
1							
2							
1							
2							
1							
2							

Comments:

Handwritten by:

Measured by:

Precipitation Rate = Δg/area (dm^2)/hr

ATTACHMENT C-IV

COLD SOAK PRECIPITATION RATE MEASUREMENT AT CEF IN OTTAWA

Date: ____________________

Start Time: ____________________

Run # : ____________________

Precip Type: ____________________ (Drizzle, Light Rain, Moderate Rain, Heavy Rain)

Pan Location:

1	2	3	4	5
6	7	8	9	10

Collection Pan:

Pan #	Area of Pan (dm^2)	Location	Weight of Pan (g)		Collection Time (hr:mm:ss)		RATE
			Before	After	Start	End	
1	14.56	1 =					
2	14.56	2 =					
3	14.56	3 =					
4	14.56	4 =					
5	14.56	5 =					
6	14.56	6 =					
7	14.56	7 =					
8	14.56	8 =					
9	14.56	9 =					
10	14.56	10 =					

Comments: ____________________

Handwritten by: ____________________

Measured by: ____________________

Precipitation Rate = Δg/area (dm^2)/hr

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ATTACHMENT C-V

TEST SCHEDULE FOR CEF

DETAILS PENDING

March 22 - March 28

March 1999

S	M	T	W	T	F	S
	1	2	3	4	5	6
7	8	9	10	11	12	13
14	15	16	17	18	19	20
21	22	23	24	25	26	27
28	29	30	31			

April 1999

S	M	T	W	T	F	S
				1	2	3
4	5	6	7	8	9	10
11	12	13	14	15	16	17
18	19	20	21	22	23	24
25	26	27	28	29	30	

March 22

March 23

HOT WATER
-3, -6, -9, -12°C
25g/dm/h
2winds

March 24

HOT WATER
-3, -6, -9, -12°C
25g/dm/h
2winds

March 25

HOT WATER
SETUP HOT (NB, MC)
-3, -6, -9, -12°C
25g/dm/h
2winds

March 26

March 27

March 28

March 29 - April 4

March 1999

S	M	T	W	T	F	S
	1	2	3	4	5	6
7	8	9	10	11	12	13
14	15	16	17	18	19	20
21	22	23	24	25	26	27
28	29	30	31			

April 1999

S	M	T	W	T	F	S
				1	2	3
4	5	6	7	8	9	10
11	12	13	14	15	16	17
18	19	20	21	22	23	24
25	26	27	28	29	30	

March 29

ZR3H
MC, JM, NB, OW1, OW2, CB
THICKNESS ATT I
M HUNT, OW3

March 30

ZR3H
MC, JM, NB, OW1, OW2, CB
THICKNESS ATT I
OW3, OW4
ZFOG ATT Z (EVENING)
MC, JD, OTHER

March 31

ZR3L
MC, JM, NB, OW1, OW2, CB
THICKNESS ATT I
OW3, OW4
FROST RESEARCH (PHASE I)
MICROSCOPE RESEARCH
ER, MM

April 1

ZD3H
MC, JM, NB, OW1, OW2, CB

April 2

Good Friday (Canada)

April 3

April 4

Easter (Canada)

April 5 -
April 11

April 1999

S	M	T	W	T	F	S
				1	2	3
4	5	6	7	8	9	10
11	12	13	14	15	16	17
18	19	20	21	22	23	24
25	26	27	28	29	30	

May 1999

S	M	T	W	T	F	S
						1
2	3	4	5	6	7	8
9	10	11	12	13	14	15
16	17	18	19	20	21	22
23	24	25	26	27	28	29
30	31					

April 5

Easter Monday (Canada)

April 6

ZD3L
MC, JM, NB, OW1, OW2, CB
NCAR (OW or APS)

April 7

ZD3L
MC, JM, NB, OW1, OW2, CB
NCAR (OW or APS)

April 8

ZD3L
MC, JM, NB, OW1, OW2, CB
NCAR (OW or APS)

April 9

ZR10H
MC, JM, NB, OW1, OW2, CB
NCAR (OW or APS)

April 10

April 11

April 12 -
April 18

April 1999

S	M	T	W	T	F	S
				1	2	3
4	5	6	7	8	9	10
11	12	13	14	15	16	17
18	19	20	21	22	23	24
25	26	27	28	29	30	

May 1999

S	M	T	W	T	F	S
						1
2	3	4	5	6	7	8
9	10	11	12	13	14	15
16	17	18	19	20	21	22
23	24	25	26	27	28	29
30	31					

April 12

ZR10L
MC, JM, NB, OW1, OW2, CB
NCAR (OW or APS)

April 13

ZD10H
MC, JM, NB, OW1, OW2, CB
NCAR (OW or APS)

April 14

ZD10L
MC, JM, NB, OW1, OW2, CB
NCAR (OW or APS)

April 15

ZD10L
MC, JM, NB, OW1, OW2, CB
NCAR (OW or APS)

April 16

FOG25H
FOG25L
MC, JM, NB, OW1, OW2, CB, OW3
NCAR (OW or APS) TRY

April 17

April 18

April 19 -
April 25

April 1999

S	M	T	W	T	F	S
				1	2	3
4	5	6	7	8	9	10
11	12	13	14	15	16	17
18	19	20	21	22	23	24
25	26	27	28	29	30	

May 1999

S	M	T	W	T	F	S
						1
2	3	4	5	6	7	8
9	10	11	12	13	14	15
16	17	18	19	20	21	22
23	24	25	26	27	28	29
30	31					

April 19

FOG 14 H
MC, JM, NB, OW1, OW2, CB, OW3

April 20

FOG 14 L
MC, JM, NB, OW1, OW2, CB, OW3

April 21

FOG 14 L
MC, JM, NB, OW1, OW2, CB, OW3

April 22

FOG 3 H
MC, JM, NB, OW1, OW2, CB, OW3

April 23

FOG 3 L
MC, JM, NB, OW1, OW2, CB, OW3

April 24

April 25

April 26 - May 2

April 1999

S	M	T	W	T	F	S
				1	2	3
4	5	6	7	8	9	10
11	12	13	14	15	16	17
18	19	20	21	22	23	24
25	26	27	28	29	30	

May 1999

S	M	T	W	T	F	S
						1
2	3	4	5	6	7	8
9	10	11	12	13	14	15
16	17	18	19	20	21	22
23	24	25	26	27	28	29
30	31					

April 26

FOG 3 L
MC, JM, NB, OW1, OW2, CB, OW3

April 27

CSW 1 H
MC, JM, NB, OW1, OW2, CB, ER, OW3

April 28

CSW 1 L
MC, JM, NB, OW1, OW2, CB, ER, OW3

April 29

SPARE DAY

April 30

SPARE DAY

May 1

May 2

CEF DETAILED TEST PLAN - Cold Soak Box

Test #	Precip Type	Temp. °C	Precip Rate g/dm^2/hr	Fluid Brand	Dilution	Viscosity	HOT Est.
45	Cold Soak Box	1	5	O MaxF	75		40
46	Cold Soak Box	1	5	O MaxF	75		40
129	Cold Soak Box	1	5	C 57	75		40
130	Cold Soak Box	1	5	C 57	75		40
213	Cold Soak Box	1	5	C SF4	75		40
214	Cold Soak Box	1	5	C SF4	75		40
297	Cold Soak Box	1	5	K ABC S	75		40
298	Cold Soak Box	1	5	K ABC S	75		40
381	Cold Soak Box	1	5	K ABC 3+	75		40
382	Cold Soak Box	1	5	K ABC 3+	75		40
41	Cold Soak Box	1	5	O MaxF	100		50
42	Cold Soak Box	1	5	O MaxF	100		50
125	Cold Soak Box	1	5	C 57	100		50
126	Cold Soak Box	1	5	C 57	100		50
209	Cold Soak Box	1	5	C SF4	100		50
210	Cold Soak Box	1	5	C SF4	100		50
293	Cold Soak Box	1	5	K ABC S	100		50
294	Cold Soak Box	1	5	K ABC S	100		50
377	Cold Soak Box	1	5	K ABC 3+	100		50
378	Cold Soak Box	1	5	K ABC 3+	100		50
437	Cold Soak Box	1	5	U Ultra+	100		50
438	Cold Soak Box	1	5	U Ultra+	100		50
499	Cold Soak Box	1	5	Fluid X	100		50
500	Cold Soak Box	1	5	Fluid X	100		50
57	Cold Soak Box	1	5	0 Eth	std		5
58	Cold Soak Box	1	5	0 Eth	std		5
59	Cold Soak Box	1	5	0 Pro	std		5
60	Cold Soak Box	1	5	0 Pro	std		5
121	Cold Soak Box	1	5	XL54	std		5
122	Cold Soak Box	1	5	XL54	std		5
123	Cold Soak Box	1	5	C I	std		5
124	Cold Soak Box	1	5	C I	std		5
47	Cold Soak Box	1	75	O MaxF	75		10
48	Cold Soak Box	1	75	O MaxF	75		10
131	Cold Soak Box	1	75	C 57	75		10
132	Cold Soak Box	1	75	C 57	75		10
215	Cold Soak Box	1	75	C SF4	75		10
216	Cold Soak Box	1	75	C SF4	75		10
299	Cold Soak Box	1	75	K ABC S	75		10
300	Cold Soak Box	1	75	K ABC S	75		10
383	Cold Soak Box	1	75	K ABC 3+	75		10
384	Cold Soak Box	1	75	K ABC 3+	75		10
43	Cold Soak Box	1	75	O MaxF	100		10
44	Cold Soak Box	1	75	O MaxF	100		10
127	Cold Soak Box	1	75	C 57	100		10
128	Cold Soak Box	1	75	C 57	100		10
211	Cold Soak Box	1	75	C SF4	100		10
212	Cold Soak Box	1	75	C SF4	100		10
295	Cold Soak Box	1	75	K ABC S	100		10
296	Cold Soak Box	1	75	K ABC S	100		10
379	Cold Soak Box	1	75	K ABC 3+	100		10
380	Cold Soak Box	1	75	K ABC 3+	100		10
439	Cold Soak Box	1	75	U Ultra+	100		10
440	Cold Soak Box	1	75	U Ultra+	100		10

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CEF DETAILED TEST PLAN - Cold Soak Box (cont.)

Test #	Precip Type	Temp. °C	Precip Rate g/dm²/hr	Fluid Brand	Dilution	Viscosity	HOT Est.
501	Cold Soak Box	1	75	Fluid X	100		10
502	Cold Soak Box	1	75	Fluid X	100		10
61	Cold Soak Box	1	75	O Eth	std		2
62	Cold Soak Box	1	75	O Eth	std		2
63	Cold Soak Box	1	75	O Pro	std		2
64	Cold Soak Box	1	75	O Pro	std		2
125	Cold Soak Box	1	75	XL54	std		2
126	Cold Soak Box	1	75	XL54	std		2
127	Cold Soak Box	1	75	C I	std		2
128	Cold Soak Box	1	75	C I	std		2

4

Total (min) = 1396

Total (hours) = 23

CEF DETAILED TEST PLAN - Freezing Drizzle

Test #	Precip Type	Temp. °C	Precip Rate g/dm²/hr	Fluid Brand	Dilution	Viscosity	HOT Est.
1	Freezing Drizzle	-3	5	O MaxF	100		120
2	Freezing Drizzle	-3	5	O MaxF	100		120
9	Freezing Drizzle	-3	5	O MaxF	75		120
10	Freezing Drizzle	-3	5	O MaxF	75		120
17	Freezing Drizzle	-3	5	O MaxF	50		60
18	Freezing Drizzle	-3	5	O MaxF	50		60
85	Freezing Drizzle	-3	5	C 57	100		120
86	Freezing Drizzle	-3	5	C 57	100		120
93	Freezing Drizzle	-3	5	C 57	75		120
94	Freezing Drizzle	-3	5	C 57	75		120
101	Freezing Drizzle	-3	5	C 57	50		60
102	Freezing Drizzle	-3	5	C 57	50		60
169	Freezing Drizzle	-3	5	C SF4	100		120
170	Freezing Drizzle	-3	5	C SF4	100		120
177	Freezing Drizzle	-3	5	C SF4	75		120
178	Freezing Drizzle	-3	5	C SF4	75		120
185	Freezing Drizzle	-3	5	C SF4	50		60
186	Freezing Drizzle	-3	5	C SF4	50		60
253	Freezing Drizzle	-3	5	K ABC S	100		120
254	Freezing Drizzle	-3	5	K ABC S	100		120
261	Freezing Drizzle	-3	5	K ABC S	75		120
262	Freezing Drizzle	-3	5	K ABC S	75		120
269	Freezing Drizzle	-3	5	K ABC S	50		60
270	Freezing Drizzle	-3	5	K ABC S	50		60
337	Freezing Drizzle	-3	5	K ABC 3+	100		120
338	Freezing Drizzle	-3	5	K ABC 3+	100		120
345	Freezing Drizzle	-3	5	K ABC 3+	75		120
346	Freezing Drizzle	-3	5	K ABC 3+	75		120
353	Freezing Drizzle	-3	5	K ABC 3+	50		60
354	Freezing Drizzle	-3	5	K ABC 3+	50		60
421	Freezing Drizzle	-3	5	U Ultra+	100		120
422	Freezing Drizzle	-3	5	U Ultra+	100		120
459	Freezing Drizzle	-3	5	Fluid X	100		120
460	Freezing Drizzle	-3	5	Fluid X	100		120
1	Freezing Drizzle	-3	5	O MaxF	100	high	120
2	Freezing Drizzle	-3	5	O MaxF	100	high	120
5	Freezing Drizzle	-3	5	K 3+	100	high	120
6	Freezing Drizzle	-3	5	K 3+	100	high	120
9	Freezing Drizzle	-3	5	K ABC-S	100	high	120
10	Freezing Drizzle	-3	5	K ABC-S	100	high	120
13	Freezing Drizzle	-3	5	C 1957	100	high	120
14	Freezing Drizzle	-3	5	C 1957	100	high	120
17	Freezing Drizzle	-3	5	C S4	100	high	120
18	Freezing Drizzle	-3	5	C S4	100	high	120
25	Freezing Drizzle	-3	5	O Eth	std		8
26	Freezing Drizzle	-3	5	O Eth	std		8
27	Freezing Drizzle	-3	5	O Pro	std		8
28	Freezing Drizzle	-3	5	O Pro	std		8
89	Freezing Drizzle	-3	5	XL54	std		8
90	Freezing Drizzle	-3	5	XL54	std		8
91	Freezing Drizzle	-3	5	C I	std		8
92	Freezing Drizzle	-3	5	C I	std		8
1	Freezing Drizzle	-3	5	Ultra+ 100			120
2	Freezing Drizzle	-3	5	Ultra+ 100			120

CEF DETAILED TEST PLAN - Freezing Drizzle

Test #	Precip Type	Temp. °C	Precip Rate g/dm²/hr	Fluid Brand	Dilution	Viscosity	HOT Est.
3	Freezing Drizzle	-3	5	Ultra+ 100			120
4	Freezing Drizzle	-3	5	Ultra+ 100 / 0 ETH			120
5	Freezing Drizzle	-3	5	Ultra+ 100 / XL54			120
6	Freezing Drizzle	-3	5	Ultra+ 100 / 0 PRO			120
7	Freezing Drizzle	-3	5	Oct Max 100			120
8	Freezing Drizzle	-3	5	Oct Max 100			120
9	Freezing Drizzle	-3	5	Oct Max 100			120
10	Freezing Drizzle	-3	5	Oct Max 100 / 0 PRO			120
11	Freezing Drizzle	-3	5	Oct Max 100 / 0 ETH			120
12	Freezing Drizzle	-3	5	Oct Max 100 / O I			120
13	Freezing Drizzle	-3	5	Ultra+ 100			120
14	Freezing Drizzle	-3	5	Ultra+ 100			120
15	Freezing Drizzle	-3	5	Ultra+ 100			120
16	Freezing Drizzle	-3	5	Ultra+ 100 / 0 ETH			120
17	Freezing Drizzle	-3	5	Ultra+ 100 / XL54			120
18	Freezing Drizzle	-3	5	Ultra+ 100 / 0 PRO			120
19	Freezing Drizzle	-3	5	Oct Max 100			120
20	Freezing Drizzle	-3	5	Oct Max 100			120
21	Freezing Drizzle	-3	5	Oct Max 100			120
22	Freezing Drizzle	-3	5	Oct Max 100 / 0 PRO			120
23	Freezing Drizzle	-3	5	Oct Max 100 / 0 ETH			120
24	Freezing Drizzle	-3	5	Oct Max 100 / O I			120
1	Freezing Drizzle	-3	5	XL54			8
2	Freezing Drizzle	-3	5	XL54			8
3	Freezing Drizzle	-3	5	XL54			8
4	Freezing Drizzle	-3	5	XL54			8
5	Freezing Drizzle	-3	5	C I			8
6	Freezing Drizzle	-3	5	C I			8
7	Freezing Drizzle	-3	5	C I			8
8	Freezing Drizzle	-3	5	C I			8
9	Freezing Drizzle	-3	5	XL54 / 0 ETH			8
10	Freezing Drizzle	-3	5	XL54 / 0 ETH			8
11	Freezing Drizzle	-3	5	XL54 / 0 PRO			8
12	Freezing Drizzle	-3	5	XL54 / 0 PRO			8
13	Freezing Drizzle	-3	5	C I / 0 ETH			8
14	Freezing Drizzle	-3	5	C I / 0 ETH			8
15	Freezing Drizzle	-3	5	C I / 0 PRO			8
16	Freezing Drizzle	-3	5	C I / 0 PRO			8
3	Freezing Drizzle	-3	13	O MaxF	100		60
4	Freezing Drizzle	-3	13	O MaxF	100		60
11	Freezing Drizzle	-3	13	O MaxF	75		80
12	Freezing Drizzle	-3	13	O MaxF	75		80
19	Freezing Drizzle	-3	13	O MaxF	50		30
20	Freezing Drizzle	-3	13	O MaxF	50		30
87	Freezing Drizzle	-3	13	C 57	100		60
88	Freezing Drizzle	-3	13	C 57	100		60
95	Freezing Drizzle	-3	13	C 57	75		80
96	Freezing Drizzle	-3	13	C 57	75		80
103	Freezing Drizzle	-3	13	C 57	50		30
104	Freezing Drizzle	-3	13	C 57	50		30
171	Freezing Drizzle	-3	13	C SF4	100		60
172	Freezing Drizzle	-3	13	C SF4	100		60
179	Freezing Drizzle	-3	13	C SF4	75		80
180	Freezing Drizzle	-3	13	C SF4	75		80

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CEF DETAILED TEST PLAN - Freezing Drizzle

Test #	Precip Type	Temp. °C	Precip Rate g/dm²/hr	Fluid Brand	Dilution	Viscosity	HOT Est.
187	Freezing Drizzle	-3	13	C SF4	50		30
188	Freezing Drizzle	-3	13	C SF4	50		30
255	Freezing Drizzle	-3	13	K ABC S	100		60
256	Freezing Drizzle	-3	13	K ABC S	100		60
263	Freezing Drizzle	-3	13	K ABC S	75		80
264	Freezing Drizzle	-3	13	K ABC S	75		80
271	Freezing Drizzle	-3	13	K ABC S	50		30
272	Freezing Drizzle	-3	13	K ABC S	50		30
339	Freezing Drizzle	-3	13	K ABC 3+	100		60
340	Freezing Drizzle	-3	13	K ABC 3+	100		60
347	Freezing Drizzle	-3	13	K ABC 3+	75		80
348	Freezing Drizzle	-3	13	K ABC 3+	75		80
355	Freezing Drizzle	-3	13	K ABC 3+	50		30
356	Freezing Drizzle	-3	13	K ABC 3+	50		30
423	Freezing Drizzle	-3	13	U Ultra+	100		60
424	Freezing Drizzle	-3	13	U Ultra+	100		60
461	Freezing Drizzle	-3	13	Fluid X	100		60
462	Freezing Drizzle	-3	13	Fluid X	100		60
29	Freezing Drizzle	-3	13	O Eth	std		5
30	Freezing Drizzle	-3	13	O Eth	std		5
31	Freezing Drizzle	-3	13	O Pro	std		5
32	Freezing Drizzle	-3	13	O Pro	std		5
93	Freezing Drizzle	-3	13	XL54	std		5
94	Freezing Drizzle	-3	13	XL54	std		5
95	Freezing Drizzle	-3	13	C I	std		5
96	Freezing Drizzle	-3	13	C I	std		5
5	Freezing Drizzle	-10	5	O MaxF	100		70
6	Freezing Drizzle	-10	5	O MaxF	100		70
13	Freezing Drizzle	-10	5	O MaxF	75		60
14	Freezing Drizzle	-10	5	O MaxF	75		60
89	Freezing Drizzle	-10	5	C 57	100		70
90	Freezing Drizzle	-10	5	C 57	100		70
97	Freezing Drizzle	-10	5	C 57	75		60
98	Freezing Drizzle	-10	5	C 57	75		60
173	Freezing Drizzle	-10	5	C SF4	100		70
174	Freezing Drizzle	-10	5	C SF4	100		70
181	Freezing Drizzle	-10	5	C SF4	75		60
182	Freezing Drizzle	-10	5	C SF4	75		60
257	Freezing Drizzle	-10	5	K ABC S	100		70
258	Freezing Drizzle	-10	5	K ABC S	100		70
265	Freezing Drizzle	-10	5	K ABC S	75		60
266	Freezing Drizzle	-10	5	K ABC S	75		60
341	Freezing Drizzle	-10	5	K ABC 3+	100		70
342	Freezing Drizzle	-10	5	K ABC 3+	100		70
349	Freezing Drizzle	-10	5	K ABC 3+	75		60
350	Freezing Drizzle	-10	5	K ABC 3+	75		60
425	Freezing Drizzle	-10	5	U Ultra+	100		70
426	Freezing Drizzle	-10	5	U Ultra+	100		70
463	Freezing Drizzle	-10	5	Fluid X	100		70
464	Freezing Drizzle	-10	5	Fluid X	100		70
3	Freezing Drizzle	-10	5	O MaxF	100	high	60
4	Freezing Drizzle	-10	5	O MaxF	100	high	60
7	Freezing Drizzle	-10	5	K 3+	100	high	60
8	Freezing Drizzle	-10	5	K 3+	100	high	60

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CEF DETAILED TEST PLAN - Freezing Drizzle

Test #	Precip Type	Temp. °C	Precip Rate g/dm²/hr	Fluid Brand	Dilution	Viscosity	HOT Est.
11	Freezing Drizzle	-10	5	K ABC-S	100	high	60
12	Freezing Drizzle	-10	5	K ABC-S	100	high	60
15	Freezing Drizzle	-10	5	C 1957	100	high	60
16	Freezing Drizzle	-10	5	C 1957	100	high	60
19	Freezing Drizzle	-10	5	C S4	100	high	60
20	Freezing Drizzle	-10	5	C S4	100	high	60
33	Freezing Drizzle	-10	5	0 Eth	std		8
34	Freezing Drizzle	-10	5	0 Eth	std		8
35	Freezing Drizzle	-10	5	0 Pro	std		8
36	Freezing Drizzle	-10	5	0 Pro	std		8
97	Freezing Drizzle	-10	5	XL54	std		8
98	Freezing Drizzle	-10	5	XL54	std		8
99	Freezing Drizzle	-10	5	C I	std		8
100	Freezing Drizzle	-10	5	C I	std		8
25	Freezing Drizzle	-10	5	Ultra + 100			60
26	Freezing Drizzle	-10	5	Ultra + 100			60
27	Freezing Drizzle	-10	5	Ultra + 100			60
28	Freezing Drizzle	-10	5	Ultra + 100 / 0 ETH			60
29	Freezing Drizzle	-10	5	Ultra + 100 / XL54			60
30	Freezing Drizzle	-10	5	Ultra + 100 / 0 PRO			60
31	Freezing Drizzle	-10	5	Oct Max 100			60
32	Freezing Drizzle	-10	5	Oct Max 100			60
33	Freezing Drizzle	-10	5	Oct Max 100			60
34	Freezing Drizzle	-10	5	Oct Max 100 / 0 PRO			60
35	Freezing Drizzle	-10	5	Oct Max 100 / 0 ETH			60
36	Freezing Drizzle	-10	5	Oct Max 100 / O I			60
37	Freezing Drizzle	-10	5	Ultra + 100			60
38	Freezing Drizzle	-10	5	Ultra + 100			60
39	Freezing Drizzle	-10	5	Ultra + 100			60
40	Freezing Drizzle	-10	5	Ultra + 100 / 0 ETH			60
41	Freezing Drizzle	-10	5	Ultra + 100 / XL54			60
42	Freezing Drizzle	-10	5	Ultra + 100 / 0 PRO			60
43	Freezing Drizzle	-10	5	Oct Max 100			60
44	Freezing Drizzle	-10	5	Oct Max 100			60
45	Freezing Drizzle	-10	5	Oct Max 100			60
46	Freezing Drizzle	-10	5	Oct Max 100 / 0 PRO			60
47	Freezing Drizzle	-10	5	Oct Max 100 / 0 ETH			60
48	Freezing Drizzle	-10	5	Oct Max 100 / O I			60
17	Freezing Drizzle	-10	5	XL54			8
18	Freezing Drizzle	-10	5	XL54			8
19	Freezing Drizzle	-10	5	XL54			8
20	Freezing Drizzle	-10	5	XL54			8
13	Freezing Drizzle	-10	5	C I			8
14	Freezing Drizzle	-10	5	C I			8
15	Freezing Drizzle	-10	5	C I			8
16	Freezing Drizzle	-10	5	C I			8
17	Freezing Drizzle	-10	5	XL54 / 0 ETH			8
18	Freezing Drizzle	-10	5	XL54 / 0 ETH			8
19	Freezing Drizzle	-10	5	XL54 / 0 PRO			8
20	Freezing Drizzle	-10	5	XL54 / 0 PRO			8
21	Freezing Drizzle	-10	5	C I / 0 ETH			8
22	Freezing Drizzle	-10	5	C I / 0 ETH			8
23	Freezing Drizzle	-10	5	C I / 0 PRO			8
24	Freezing Drizzle	-10	5	C I / 0 PRO			8

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CEF DETAILED TEST PLAN - Freezing Drizzle

Test #	Precip Type	Temp. °C	Precip Rate g/dm²/hr	Fluid Brand	Dilution	Viscosity	HOT Est.
7	Freezing Drizzle	-10	13	O MaxF	100		30
8	Freezing Drizzle	-10	13	O MaxF	100		30
15	Freezing Drizzle	-10	13	O MaxF	75		30
16	Freezing Drizzle	-10	13	O MaxF	75		30
91	Freezing Drizzle	-10	13	C 57	100		30
92	Freezing Drizzle	-10	13	C 57	100		30
99	Freezing Drizzle	-10	13	C 57	75		30
100	Freezing Drizzle	-10	13	C 57	75		30
175	Freezing Drizzle	-10	13	C SF4	100		30
176	Freezing Drizzle	-10	13	C SF4	100		30
183	Freezing Drizzle	-10	13	C SF4	75		30
184	Freezing Drizzle	-10	13	C SF4	75		30
259	Freezing Drizzle	-10	13	K ABC S	100		30
260	Freezing Drizzle	-10	13	K ABC S	100		30
267	Freezing Drizzle	-10	13	K ABC S	75		30
268	Freezing Drizzle	-10	13	K ABC S	75		30
343	Freezing Drizzle	-10	13	K ABC 3+	100		30
344	Freezing Drizzle	-10	13	K ABC 3+	100		30
351	Freezing Drizzle	-10	13	K ABC 3+	75		30
352	Freezing Drizzle	-10	13	K ABC 3+	75		30
427	Freezing Drizzle	-10	13	U Ultra+	100		30
428	Freezing Drizzle	-10	13	U Ultra+	100		30
465	Freezing Drizzle	-10	13	Fluid X	100		30
466	Freezing Drizzle	-10	13	Fluid X	100		30
37	Freezing Drizzle	-10	13	0 Eth	std		5
38	Freezing Drizzle	-10	13	0 Eth	std		5
39	Freezing Drizzle	-10	13	0 Pro	std		5
40	Freezing Drizzle	-10	13	0 Pro	std		5
101	Freezing Drizzle	-10	13	XL54	std		5
102	Freezing Drizzle	-10	13	XL54	std		5
103	Freezing Drizzle	-10	13	C I	std		5
104	Freezing Drizzle	-10	13	C I	std		5

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Total (min) = 14304

Total (hours) = 238

CEF DETAILED TEST PLAN - Freezing Fog

Test #	Precip Type	Temp. °C	Precip Rate g/dm²/hr	Fluid Brand	Dilution	Viscosity	HOT Est.
49	Freezing Fog	-3	2	O MaxF	100		180
50	Freezing Fog	-3	2	O MaxF	100		180
61	Freezing Fog	-3	2	O MaxF	75		120
62	Freezing Fog	-3	2	O MaxF	75		120
69	Freezing Fog	-3	2	O MaxF	50		50
70	Freezing Fog	-3	2	O MaxF	50		50
73	Freezing Fog	-3	2	O MaxF	100		180
79	Freezing Fog	-3	2	O MaxF	75		120
83	Freezing Fog	-3	2	O MaxF	50		50
133	Freezing Fog	-3	2	C 57	100		180
134	Freezing Fog	-3	2	C 57	100		180
145	Freezing Fog	-3	2	C 57	75		120
146	Freezing Fog	-3	2	C 57	75		120
153	Freezing Fog	-3	2	C 57	50		50
154	Freezing Fog	-3	2	C 57	50		50
157	Freezing Fog	-3	2	C 57	100		180
163	Freezing Fog	-3	2	C 57	75		120
167	Freezing Fog	-3	2	C 57	50		50
217	Freezing Fog	-3	2	C SF4	100		180
218	Freezing Fog	-3	2	C SF4	100		180
229	Freezing Fog	-3	2	C SF4	75		120
230	Freezing Fog	-3	2	C SF4	75		120
237	Freezing Fog	-3	2	C SF4	50		50
238	Freezing Fog	-3	2	C SF4	50		50
241	Freezing Fog	-3	2	C SF4	100		180
247	Freezing Fog	-3	2	C SF4	75		120
251	Freezing Fog	-3	2	C SF4	50		50
301	Freezing Fog	-3	2	K ABC S	100		180
302	Freezing Fog	-3	2	K ABC S	100		180
313	Freezing Fog	-3	2	K ABC S	75		120
314	Freezing Fog	-3	2	K ABC S	75		120
321	Freezing Fog	-3	2	K ABC S	50		50
322	Freezing Fog	-3	2	K ABC S	50		50
325	Freezing Fog	-3	2	K ABC S	100		180
331	Freezing Fog	-3	2	K ABC S	75		120
335	Freezing Fog	-3	2	K ABC S	50		50
385	Freezing Fog	-3	2	K ABC 3+	100		180
386	Freezing Fog	-3	2	K ABC 3+	100		180
397	Freezing Fog	-3	2	K ABC 3+	75		120
398	Freezing Fog	-3	2	K ABC 3+	75		120
405	Freezing Fog	-3	2	K ABC 3+	50		50
406	Freezing Fog	-3	2	K ABC 3+	50		50
409	Freezing Fog	-3	2	K ABC 3+	100		180
415	Freezing Fog	-3	2	K ABC 3+	75		120
419	Freezing Fog	-3	2	K ABC 3+	50		50
441	Freezing Fog	-3	2	U Ultra+	100		180
442	Freezing Fog	-3	2	U Ultra+	100		180
453	Freezing Fog	-3	2	U Ultra+	100		180
507	Freezing Fog	-3	2	Fluid X	100		180
508	Freezing Fog	-3	2	Fluid X	100		180
531	Freezing Fog	-3	2	Fluid X	100		180

CEF DETAILED TEST PLAN - Freezing Fog (cont.)

Test #	Precip Type	Temp. °C	Precip Rate g/dm²/hr	Fluid Brand	Dilution	Viscosity	HOT Est.
1	Freezing Fog	-3	2	O Eth	std		30
2	Freezing Fog	-3	2	O Eth	std		30
3	Freezing Fog	-3	2	O Pro	std		30
4	Freezing Fog	-3	2	O Pro	std		30
65	Freezing Fog	-3	2	XL54	std		30
66	Freezing Fog	-3	2	XL54	std		30
67	Freezing Fog	-3	2	C I	std		30
68	Freezing Fog	-3	2	C I	std		30
51	Freezing Fog	-3	5	O MaxF	100		120
52	Freezing Fog	-3	5	O MaxF	100		120
63	Freezing Fog	-3	5	O MaxF	75		70
64	Freezing Fog	-3	5	O MaxF	75		70
71	Freezing Fog	-3	5	O MaxF	50		20
72	Freezing Fog	-3	5	O MaxF	50		20
74	Freezing Fog	-3	5	O MaxF	100		120
80	Freezing Fog	-3	5	O MaxF	75		70
84	Freezing Fog	-3	5	O MaxF	50		20
135	Freezing Fog	-3	5	C 57	100		120
136	Freezing Fog	-3	5	C 57	100		120
147	Freezing Fog	-3	5	C 57	75		70
148	Freezing Fog	-3	5	C 57	75		70
155	Freezing Fog	-3	5	C 57	50		20
156	Freezing Fog	-3	5	C 57	50		20
158	Freezing Fog	-3	5	C 57	100		120
164	Freezing Fog	-3	5	C 57	75		70
168	Freezing Fog	-3	5	C 57	50		20
219	Freezing Fog	-3	5	C SF4	100		120
220	Freezing Fog	-3	5	C SF4	100		120
231	Freezing Fog	-3	5	C SF4	75		70
232	Freezing Fog	-3	5	C SF4	75		70
239	Freezing Fog	-3	5	C SF4	50		20
240	Freezing Fog	-3	5	C SF4	50		20
242	Freezing Fog	-3	5	C SF4	100		120
248	Freezing Fog	-3	5	C SF4	75		70
252	Freezing Fog	-3	5	C SF4	50		20
303	Freezing Fog	-3	5	K ABC S	100		120
304	Freezing Fog	-3	5	K ABC S	100		120
315	Freezing Fog	-3	5	K ABC S	75		70
316	Freezing Fog	-3	5	K ABC S	75		70
323	Freezing Fog	-3	5	K ABC S	50		20
324	Freezing Fog	-3	5	K ABC S	50		20
326	Freezing Fog	-3	5	K ABC S	100		120
332	Freezing Fog	-3	5	K ABC S	75		70
336	Freezing Fog	-3	5	K ABC S	50		20
387	Freezing Fog	-3	5	K ABC 3+	100		120
388	Freezing Fog	-3	5	K ABC 3+	100		120
399	Freezing Fog	-3	5	K ABC 3+	75		70
400	Freezing Fog	-3	5	K ABC 3+	75		70
407	Freezing Fog	-3	5	K ABC 3+	50		20
408	Freezing Fog	-3	5	K ABC 3+	50		20
410	Freezing Fog	-3	5	K ABC 3+	100		120

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CEF DETAILED TEST PLAN - Freezing Fog (cont.)

Test #	Precip Type	Temp. °C	Precip Rate g/dm²/hr	Fluid Brand	Dilution	Viscosity	HOT Est.
416	Freezing Fog	-3	5	K ABC 3+	75		70
420	Freezing Fog	-3	5	K ABC 3+	50		20
443	Freezing Fog	-3	5	U Ultra+	100		120
444	Freezing Fog	-3	5	U Ultra+	100		120
454	Freezing Fog	-3	5	U Ultra+	100		120
509	Freezing Fog	-3	5	Fluid X	100		120
510	Freezing Fog	-3	5	Fluid X	100		120
532	Freezing Fog	-3	5	Fluid X	100		120
5	Freezing Fog	-3	5	O Eth	std		12
6	Freezing Fog	-3	5	O Eth	std		12
7	Freezing Fog	-3	5	O Pro	std		12
8	Freezing Fog	-3	5	O Pro	std		12
69	Freezing Fog	-3	5	XL54	std		12
70	Freezing Fog	-3	5	XL54	std		12
71	Freezing Fog	-3	5	C I	std		12
72	Freezing Fog	-3	5	C I	std		12
53	Freezing Fog	-14	2	O MaxF	100		180
54	Freezing Fog	-14	2	O MaxF	100		180
65	Freezing Fog	-14	2	O MaxF	75		120
66	Freezing Fog	-14	2	O MaxF	75		120
75	Freezing Fog	-14	2	O MaxF	100		180
81	Freezing Fog	-14	2	O MaxF	75		120
137	Freezing Fog	-14	2	C 57	100		180
138	Freezing Fog	-14	2	C 57	100		180
149	Freezing Fog	-14	2	C 57	75		120
150	Freezing Fog	-14	2	C 57	75		120
159	Freezing Fog	-14	2	C 57	100		180
165	Freezing Fog	-14	2	C 57	75		120
221	Freezing Fog	-14	2	C SF4	100		180
222	Freezing Fog	-14	2	C SF4	100		180
233	Freezing Fog	-14	2	C SF4	75		120
234	Freezing Fog	-14	2	C SF4	75		120
243	Freezing Fog	-14	2	C SF4	100		180
249	Freezing Fog	-14	2	C SF4	75		120
305	Freezing Fog	-14	2	K ABC S	100		180
306	Freezing Fog	-14	2	K ABC S	100		180
317	Freezing Fog	-14	2	K ABC S	75		120
318	Freezing Fog	-14	2	K ABC S	75		120
327	Freezing Fog	-14	2	K ABC S	100		180
333	Freezing Fog	-14	2	K ABC S	75		120
389	Freezing Fog	-14	2	K ABC 3+	100		180
390	Freezing Fog	-14	2	K ABC 3+	100		180
401	Freezing Fog	-14	2	K ABC 3+	75		120
402	Freezing Fog	-14	2	K ABC 3+	75		120
411	Freezing Fog	-14	2	K ABC 3+	100		180
417	Freezing Fog	-14	2	K ABC 3+	75		120
445	Freezing Fog	-14	2	U Ultra+	100		180
446	Freezing Fog	-14	2	U Ultra+	100		180
455	Freezing Fog	-14	2	U Ultra+	100		180
511	Freezing Fog	-14	2	Fluid X	100		180
512	Freezing Fog	-14	2	Fluid X	100		180

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CEF DETAILED TEST PLAN - Freezing Fog (cont.)

Test #	Precip Type	Temp. °C	Precip Rate g/dm²/hr	Fluid Brand	Dilution	Viscosity	HOT Est.
533	Freezing Fog	-14	2	Fluid X	100		180
9	Freezing Fog	-14	2	O Eth	std		15
10	Freezing Fog	-14	2	O Eth	std		15
11	Freezing Fog	-14	2	O Pro	std		15
12	Freezing Fog	-14	2	O Pro	std		15
73	Freezing Fog	-14	2	XL54	std		15
74	Freezing Fog	-14	2	XL54	std		15
75	Freezing Fog	-14	2	C I	std		15
76	Freezing Fog	-14	2	C I	std		15
55	Freezing Fog	-14	5	O MaxF	100		40
56	Freezing Fog	-14	5	O MaxF	100		40
67	Freezing Fog	-14	5	O MaxF	75		30
68	Freezing Fog	-14	5	O MaxF	75		30
76	Freezing Fog	-14	5	O MaxF	100		40
82	Freezing Fog	-14	5	O MaxF	75		30
139	Freezing Fog	-14	5	C 57	100		40
140	Freezing Fog	-14	5	C 57	100		40
151	Freezing Fog	-14	5	C 57	75		30
152	Freezing Fog	-14	5	C 57	75		30
160	Freezing Fog	-14	5	C 57	100		40
166	Freezing Fog	-14	5	C 57	75		30
223	Freezing Fog	-14	5	C SF4	100		40
224	Freezing Fog	-14	5	C SF4	100		40
235	Freezing Fog	-14	5	C SF4	75		30
236	Freezing Fog	-14	5	C SF4	75		30
244	Freezing Fog	-14	5	C SF4	100		40
250	Freezing Fog	-14	5	C SF4	75		30
307	Freezing Fog	-14	5	K ABC S	100		40
308	Freezing Fog	-14	5	K ABC S	100		40
319	Freezing Fog	-14	5	K ABC S	75		30
320	Freezing Fog	-14	5	K ABC S	75		30
328	Freezing Fog	-14	5	K ABC S	100		40
334	Freezing Fog	-14	5	K ABC S	75		30
391	Freezing Fog	-14	5	K ABC 3+	100		40
392	Freezing Fog	-14	5	K ABC 3+	100		40
403	Freezing Fog	-14	5	K ABC 3+	75		30
404	Freezing Fog	-14	5	K ABC 3+	75		30
412	Freezing Fog	-14	5	K ABC 3+	100		40
418	Freezing Fog	-14	5	K ABC 3+	75		30
447	Freezing Fog	-14	5	U Ultra+	100		40
448	Freezing Fog	-14	5	U Ultra+	100		40
456	Freezing Fog	-14	5	U Ultra+	100		40
513	Freezing Fog	-14	5	Fluid X	100		40
514	Freezing Fog	-14	5	Fluid X	100		40
534	Freezing Fog	-14	5	Fluid X	100		40
13	Freezing Fog	-14	5	O Eth	std		6
14	Freezing Fog	-14	5	O Eth	std		6
15	Freezing Fog	-14	5	O Pro	std		6
16	Freezing Fog	-14	5	O Pro	std		6
77	Freezing Fog	-14	5	XL54	std		6
78	Freezing Fog	-14	5	XL54	std		6

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CEF DETAILED TEST PLAN - Freezing Fog (cont.)

Test #	Precip Type	Temp. °C	Precip Rate g/dm²/hr	Fluid Brand	Dilution	Viscosity	HOT Est.	
79	Freezing Fog	-14	5	C I	std		6	
80	Freezing Fog	-14	5	C I	std		6	22
57	Freezing Fog	-25	2	O MaxF	100		120	
58	Freezing Fog	-25	2	O MaxF	100		120	
77	Freezing Fog	-25	2	O MaxF	100		120	
141	Freezing Fog	-25	2	C 57	100		120	
142	Freezing Fog	-25	2	C 57	100		120	
161	Freezing Fog	-25	2	C 57	100		120	
225	Freezing Fog	-25	2	C SF4	100		120	
226	Freezing Fog	-25	2	C SF4	100		120	
245	Freezing Fog	-25	2	C SF4	100		120	
309	Freezing Fog	-25	2	K ABC S	100		120	
310	Freezing Fog	-25	2	K ABC S	100		120	
329	Freezing Fog	-25	2	K ABC S	100		120	
393	Freezing Fog	-25	2	K ABC 3+	100		120	
394	Freezing Fog	-25	2	K ABC 3+	100		120	
413	Freezing Fog	-25	2	K ABC 3+	100		120	
449	Freezing Fog	-25	2	U Ultra+	100		120	
450	Freezing Fog	-25	2	U Ultra+	100		120	
457	Freezing Fog	-25	2	U Ultra+	100		120	
515	Freezing Fog	-25	2	Fluid X	100		120	
516	Freezing Fog	-25	2	Fluid X	100		120	
535	Freezing Fog	-25	2	Fluid X	100		120	
17	Freezing Fog	-25	2	O Eth	std		15	
18	Freezing Fog	-25	2	O Eth	std		15	
19	Freezing Fog	-25	2	O Pro	std		15	
20	Freezing Fog	-25	2	O Pro	std		15	
81	Freezing Fog	-25	2	XL54	std		15	
82	Freezing Fog	-25	2	XL54	std		15	
83	Freezing Fog	-25	2	C I	std		15	
84	Freezing Fog	-25	2	C I	std		15	44
59	Freezing Fog	-25	5	O MaxF	100		20	
60	Freezing Fog	-25	5	O MaxF	100		20	
78	Freezing Fog	-25	5	O MaxF	100		20	
143	Freezing Fog	-25	5	C 57	100		20	
144	Freezing Fog	-25	5	C 57	100		20	
162	Freezing Fog	-25	5	C 57	100		20	
227	Freezing Fog	-25	5	C SF4	100		20	
228	Freezing Fog	-25	5	C SF4	100		20	
246	Freezing Fog	-25	5	C SF4	100		20	
311	Freezing Fog	-25	5	K ABC S	100		20	
312	Freezing Fog	-25	5	K ABC S	100		20	
330	Freezing Fog	-25	5	K ABC S	100		20	
395	Freezing Fog	-25	5	K ABC 3+	100		20	
396	Freezing Fog	-25	5	K ABC 3+	100		20	
414	Freezing Fog	-25	5	K ABC 3+	100		20	
451	Freezing Fog	-25	5	U Ultra+	100		20	
452	Freezing Fog	-25	5	U Ultra+	100		20	
458	Freezing Fog	-25	5	U Ultra+	100		20	
517	Freezing Fog	-25	5	Fluid X	100		20	
518	Freezing Fog	-25	5	Fluid X	100		20	

CEF DETAILED TEST PLAN - Freezing Fog (cont.)

Test #	Precip Type	Temp. °C	Precip Rate g/dm²/hr	Fluid Brand	Dilution	Viscosity	HOT Est.
536	Freezing Fog	-25	5	Fluid X	100		20
21	Freezing Fog	-25	5	0 Eth	std		6
22	Freezing Fog	-25	5	0 Eth	std		6
23	Freezing Fog	-25	5	0 Pro	std		6
24	Freezing Fog	-25	5	0 Pro	std		6
85	Freezing Fog	-25	5	XL54	std		6
86	Freezing Fog	-25	5	XL54	std		6
87	Freezing Fog	-25	5	C I	std		6
88	Freezing Fog	-25	5	C I	std		6

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Total (min) = 20682

Total (hours) = 345

CEF DETAILED TEST PLAN - Light Freezing Rain

Test #	Precip Type	Temp. °C	Precip Rate g/dm²/hr	Fluid Brand	Dilution	Viscosity	HOT Est.
21	Light Freezing Rain	-3	13	O MaxF	100		60
22	Light Freezing Rain	-3	13	O MaxF	100		60
29	Light Freezing Rain	-3	13	O MaxF	75		70
30	Light Freezing Rain	-3	13	O MaxF	75		70
37	Light Freezing Rain	-3	13	O MaxF	50		30
38	Light Freezing Rain	-3	13	O MaxF	50		30
105	Light Freezing Rain	-3	13	C 57	100		60
106	Light Freezing Rain	-3	13	C 57	100		60
113	Light Freezing Rain	-3	13	C 57	75		70
114	Light Freezing Rain	-3	13	C 57	75		70
121	Light Freezing Rain	-3	13	C 57	50		30
122	Light Freezing Rain	-3	13	C 57	50		30
189	Light Freezing Rain	-3	13	C SF4	100		60
190	Light Freezing Rain	-3	13	C SF4	100		60
197	Light Freezing Rain	-3	13	C SF4	75		70
198	Light Freezing Rain	-3	13	C SF4	75		70
205	Light Freezing Rain	-3	13	C SF4	50		30
206	Light Freezing Rain	-3	13	C SF4	50		30
273	Light Freezing Rain	-3	13	K ABC S	100		60
274	Light Freezing Rain	-3	13	K ABC S	100		60
281	Light Freezing Rain	-3	13	K ABC S	75		70
282	Light Freezing Rain	-3	13	K ABC S	75		70
289	Light Freezing Rain	-3	13	K ABC S	50		30
290	Light Freezing Rain	-3	13	K ABC S	50		30
357	Light Freezing Rain	-3	13	K ABC 3+	100		60
358	Light Freezing Rain	-3	13	K ABC 3+	100		60
365	Light Freezing Rain	-3	13	K ABC 3+	75		70
366	Light Freezing Rain	-3	13	K ABC 3+	75		70
373	Light Freezing Rain	-3	13	K ABC 3+	50		30
374	Light Freezing Rain	-3	13	K ABC 3+	50		30
429	Light Freezing Rain	-3	13	U Ultra+	100		60
430	Light Freezing Rain	-3	13	U Ultra+	100		60
479	Light Freezing Rain	-3	13	Fluid X	100		60
480	Light Freezing Rain	-3	13	Fluid X	100		60
41	Light Freezing Rain	-3	13	O Eth	std		5
42	Light Freezing Rain	-3	13	O Eth	std		5
43	Light Freezing Rain	-3	13	O Pro	std		5
44	Light Freezing Rain	-3	13	O Pro	std		5
105	Light Freezing Rain	-3	13	XL54	std		5
106	Light Freezing Rain	-3	13	XL54	std		5
107	Light Freezing Rain	-3	13	C I	std		5
108	Light Freezing Rain	-3	13	C I	std		5
23	Light Freezing Rain	-3	25	O MaxF	100		40
24	Light Freezing Rain	-3	25	O MaxF	100		40
31	Light Freezing Rain	-3	25	O MaxF	75		40
32	Light Freezing Rain	-3	25	O MaxF	75		40
39	Light Freezing Rain	-3	25	O MaxF	50		20
40	Light Freezing Rain	-3	25	O MaxF	50		20
107	Light Freezing Rain	-3	25	C 57	100		40
108	Light Freezing Rain	-3	25	C 57	100		40
115	Light Freezing Rain	-3	25	C 57	75		40

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CEF DETAILED TEST PLAN - Light Freezing Rain (cont.)

Test #	Precip Type	Temp. °C	Precip Rate g/dm²/hr	Fluid Brand	Dilution	Viscosity	HOT Est.
116	Light Freezing Rain	-3	25	C 57	75		40
123	Light Freezing Rain	-3	25	C 57	50		20
124	Light Freezing Rain	-3	25	C 57	50		20
191	Light Freezing Rain	-3	25	C SF4	100		40
192	Light Freezing Rain	-3	25	C SF4	100		40
199	Light Freezing Rain	-3	25	C SF4	75		40
200	Light Freezing Rain	-3	25	C SF4	75		40
207	Light Freezing Rain	-3	25	C SF4	50		20
208	Light Freezing Rain	-3	25	C SF4	50		20
275	Light Freezing Rain	-3	25	K ABC S	100		40
276	Light Freezing Rain	-3	25	K ABC S	100		40
283	Light Freezing Rain	-3	25	K ABC S	75		40
284	Light Freezing Rain	-3	25	K ABC S	75		40
291	Light Freezing Rain	-3	25	K ABC S	50		20
292	Light Freezing Rain	-3	25	K ABC S	50		20
359	Light Freezing Rain	-3	25	K ABC 3+	100		40
360	Light Freezing Rain	-3	25	K ABC 3+	100		40
367	Light Freezing Rain	-3	25	K ABC 3+	75		40
368	Light Freezing Rain	-3	25	K ABC 3+	75		40
375	Light Freezing Rain	-3	25	K ABC 3+	50		20
376	Light Freezing Rain	-3	25	K ABC 3+	50		20
431	Light Freezing Rain	-3	25	U Ultra+	100		40
432	Light Freezing Rain	-3	25	U Ultra+	100		40
481	Light Freezing Rain	-3	25	Fluid X	100		40
482	Light Freezing Rain	-3	25	Fluid X	100		40
21	Light Freezing Rain	-3	25	O MaxF	100	high	120
22	Light Freezing Rain	-3	25	O MaxF	100	high	120
25	Light Freezing Rain	-3	25	K 3+	100	high	120
26	Light Freezing Rain	-3	25	K 3+	100	high	120
29	Light Freezing Rain	-3	25	K ABC-S	100	high	120
30	Light Freezing Rain	-3	25	K ABC-S	100	high	120
33	Light Freezing Rain	-3	25	C 1957	100	high	120
34	Light Freezing Rain	-3	25	C 1957	100	high	120
37	Light Freezing Rain	-3	25	C S4	100	high	120
38	Light Freezing Rain	-3	25	C S4	100	high	120
45	Light Freezing Rain	-3	25	0 Eth	std		2
46	Light Freezing Rain	-3	25	0 Eth	std		2
47	Light Freezing Rain	-3	25	0 Pro	std		2
48	Light Freezing Rain	-3	25	0 Pro	std		2
109	Light Freezing Rain	-3	25	XL54	std		2
110	Light Freezing Rain	-3	25	XL54	std		2
111	Light Freezing Rain	-3	25	C I	std		2
112	Light Freezing Rain	-3	25	C I	std		2
49	Light Freezing Rain	-3	25	Ultra+ 100			40
50	Light Freezing Rain	-3	25	Ultra+ 100			40
51	Light Freezing Rain	-3	25	Ultra+ 100			40
52	Light Freezing Rain	-3	25	Ultra+ 100 / 0 ETH			40
53	Light Freezing Rain	-3	25	Ultra+ 100 / XL54			40
54	Light Freezing Rain	-3	25	Ultra+ 100 / 0 PRO			40
55	Light Freezing Rain	-3	25	Oct Max 100			40
56	Light Freezing Rain	-3	25	Oct Max 100			40

CEF DETAILED TEST PLAN - Light Freezing Rain (cont.)

Test #	Precip Type	Temp. °C	Precip Rate g/dm²/hr	Fluid Brand	Dilution	Viscosity	HOT Est.
57	Light Freezing Rain	-3	25	Oct Max 100			40
58	Light Freezing Rain	-3	25	Oct Max 100 / 0 PRO			40
59	Light Freezing Rain	-3	25	Oct Max 100 / 0 ETH			40
60	Light Freezing Rain	-3	25	Oct Max 100 / O I			40
61	Light Freezing Rain	-3	25	Ultra+ 100			40
62	Light Freezing Rain	-3	25	Ultra+ 100			40
63	Light Freezing Rain	-3	25	Ultra+ 100			40
64	Light Freezing Rain	-3	25	Ultra+ 100 / 0 ETH			40
65	Light Freezing Rain	-3	25	Ultra+ 100 / XL54			40
66	Light Freezing Rain	-3	25	Ultra+ 100 / 0 PRO			40
67	Light Freezing Rain	-3	25	Oct Max 100			40
68	Light Freezing Rain	-3	25	Oct Max 100			40
69	Light Freezing Rain	-3	25	Oct Max 100			40
70	Light Freezing Rain	-3	25	Oct Max 100 / 0 PRO			40
71	Light Freezing Rain	-3	25	Oct Max 100 / 0 ETH			40
72	Light Freezing Rain	-3	25	Oct Max 100 / O I			40
25	Light Freezing Rain	-3	25	XL54			2
26	Light Freezing Rain	-3	25	XL54			2
27	Light Freezing Rain	-3	25	XL54			2
28	Light Freezing Rain	-3	25	XL54			2
29	Light Freezing Rain	-3	25	C I			2
30	Light Freezing Rain	-3	25	C I			2
31	Light Freezing Rain	-3	25	C I			2
32	Light Freezing Rain	-3	25	C I			2
33	Light Freezing Rain	-3	25	XL54 / 0 ETH			2
34	Light Freezing Rain	-3	25	XL54 / 0 ETH			2
35	Light Freezing Rain	-3	25	XL54 / 0 PRO			2
36	Light Freezing Rain	-3	25	XL54 / 0 PRO			2
37	Light Freezing Rain	-3	25	C I / 0 ETH			2
38	Light Freezing Rain	-3	25	C I / 0 ETH			2
39	Light Freezing Rain	-3	25	C I / 0 PRO			2
40	Light Freezing Rain	-3	25	C I / 0 PRO			2
25	Light Freezing Rain	-10	13	O MaxF	100		40
26	Light Freezing Rain	-10	13	O MaxF	100		40
33	Light Freezing Rain	-10	13	O MaxF	75		30
34	Light Freezing Rain	-10	13	O MaxF	75		30
109	Light Freezing Rain	-10	13	C 57	100		40
110	Light Freezing Rain	-10	13	C 57	100		40
117	Light Freezing Rain	-10	13	C 57	75		30
118	Light Freezing Rain	-10	13	C 57	75		30
193	Light Freezing Rain	-10	13	C SF4	100		40
194	Light Freezing Rain	-10	13	C SF4	100		40
201	Light Freezing Rain	-10	13	C SF4	75		30
202	Light Freezing Rain	-10	13	C SF4	75		30
277	Light Freezing Rain	-10	13	K ABC S	100		40
278	Light Freezing Rain	-10	13	K ABC S	100		40
285	Light Freezing Rain	-10	13	K ABC S	75		30
286	Light Freezing Rain	-10	13	K ABC S	75		30
361	Light Freezing Rain	-10	13	K ABC 3+	100		40
362	Light Freezing Rain	-10	13	K ABC 3+	100		40
369	Light Freezing Rain	-10	13	K ABC 3+	75		30

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CEF DETAILED TEST PLAN - Light Freezing Rain (cont.)

Test #	Precip Type	Temp. °C	Precip Rate g/dm²/hr	Fluid Brand	Dilution	Viscosity	HOT Est.
370	Light Freezing Rain	-10	13	K ABC 3+	75		30
433	Light Freezing Rain	-10	13	U Ultra+	100		40
434	Light Freezing Rain	-10	13	U Ultra+	100		40
483	Light Freezing Rain	-10	13	Fluid X	100		40
484	Light Freezing Rain	-10	13	Fluid X	100		40
49	Light Freezing Rain	-10	13	0 Eth	std		5
50	Light Freezing Rain	-10	13	0 Eth	std		5
51	Light Freezing Rain	-10	13	0 Pro	std		5
52	Light Freezing Rain	-10	13	0 Pro	std		5
113	Light Freezing Rain	-10	13	XL54	std		5
114	Light Freezing Rain	-10	13	XL54	std		5
115	Light Freezing Rain	-10	13	C I	std		5
116	Light Freezing Rain	-10	13	C I	std		5
27	Light Freezing Rain	-10	25	O MaxF	100		20
28	Light Freezing Rain	-10	25	O MaxF	100		20
35	Light Freezing Rain	-10	25	O MaxF	75		20
36	Light Freezing Rain	-10	25	O MaxF	75		20
111	Light Freezing Rain	-10	25	C 57	100		20
112	Light Freezing Rain	-10	25	C 57	100		20
119	Light Freezing Rain	-10	25	C 57	75		20
120	Light Freezing Rain	-10	25	C 57	75		20
195	Light Freezing Rain	-10	25	C SF4	100		20
196	Light Freezing Rain	-10	25	C SF4	100		20
203	Light Freezing Rain	-10	25	C SF4	75		20
204	Light Freezing Rain	-10	25	C SF4	75		20
279	Light Freezing Rain	-10	25	K ABC S	100		20
280	Light Freezing Rain	-10	25	K ABC S	100		20
287	Light Freezing Rain	-10	25	K ABC S	75		20
288	Light Freezing Rain	-10	25	K ABC S	75		20
363	Light Freezing Rain	-10	25	K ABC 3+	100		20
364	Light Freezing Rain	-10	25	K ABC 3+	100		20
371	Light Freezing Rain	-10	25	K ABC 3+	75		20
372	Light Freezing Rain	-10	25	K ABC 3+	75		20
435	Light Freezing Rain	-10	25	U Ultra+	100		20
436	Light Freezing Rain	-10	25	U Ultra+	100		20
485	Light Freezing Rain	-10	25	Fluid X	100		20
486	Light Freezing Rain	-10	25	Fluid X	100		20
23	Light Freezing Rain	-10	25	O MaxF	100	high	60
24	Light Freezing Rain	-10	25	O MaxF	100	high	60
27	Light Freezing Rain	-10	25	K 3+	100	high	60
28	Light Freezing Rain	-10	25	K 3+	100	high	60
31	Light Freezing Rain	-10	25	K ABC-S	100	high	60
32	Light Freezing Rain	-10	25	K ABC-S	100	high	60
35	Light Freezing Rain	-10	25	C 1957	100	high	60
36	Light Freezing Rain	-10	25	C 1957	100	high	60
39	Light Freezing Rain	-10	25	C S4	100	high	60
40	Light Freezing Rain	-10	25	C S4	100	high	60
53	Light Freezing Rain	-10	25	0 Eth	std		2
54	Light Freezing Rain	-10	25	0 Eth	std		2
55	Light Freezing Rain	-10	25	0 Pro	std		2
56	Light Freezing Rain	-10	25	0 Pro	std		2

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CEF DETAILED TEST PLAN - Light Freezing Rain (cont.)

Test #	Precip Type	Temp. °C	Precip Rate $g/dm^2/hr$	Fluid Brand	Dilution	Viscosity	HOT Est.
117	Light Freezing Rain	-10	25	XL54	std		2
118	Light Freezing Rain	-10	25	XL54	std		2
119	Light Freezing Rain	-10	25	C I	std		2
120	Light Freezing Rain	-10	25	C I	std		2
73	Light Freezing Rain	-10	25	Ultra + 100			20
74	Light Freezing Rain	-10	25	Ultra + 100			20
75	Light Freezing Rain	-10	25	Ultra + 100			20
76	Light Freezing Rain	-10	25	Ultra + 100 / 0 ETH			20
77	Light Freezing Rain	-10	25	Ultra + 100 / XL54			20
78	Light Freezing Rain	-10	25	Ultra + 100 / 0 PRO			20
79	Light Freezing Rain	-10	25	Oct Max 100			20
80	Light Freezing Rain	-10	25	Oct Max 100			20
81	Light Freezing Rain	-10	25	Oct Max 100			20
82	Light Freezing Rain	-10	25	Oct Max 100 / 0 PRO			20
83	Light Freezing Rain	-10	25	Oct Max 100 / 0 ETH			20
84	Light Freezing Rain	-10	25	Oct Max 100 / 0 I			20
85	Light Freezing Rain	-10	25	Ultra + 100			20
86	Light Freezing Rain	-10	25	Ultra + 100			20
87	Light Freezing Rain	-10	25	Ultra + 100			20
88	Light Freezing Rain	-10	25	Ultra + 100 / 0 ETH			20
89	Light Freezing Rain	-10	25	Ultra + 100 / XL54			20
90	Light Freezing Rain	-10	25	Ultra + 100 / 0 PRO			20
91	Light Freezing Rain	-10	25	Oct Max 100			20
92	Light Freezing Rain	-10	25	Oct Max 100			20
93	Light Freezing Rain	-10	25	Oct Max 100			20
94	Light Freezing Rain	-10	25	Oct Max 100 / 0 PRO			20
95	Light Freezing Rain	-10	25	Oct Max 100 / 0 ETH			20
96	Light Freezing Rain	-10	25	Oct Max 100 / 0 I			20
41	Light Freezing Rain	-10	25	XL54			2
42	Light Freezing Rain	-10	25	XL54			2
43	Light Freezing Rain	-10	25	XL54			2
44	Light Freezing Rain	-10	25	XL54			2
45	Light Freezing Rain	-10	25	C I			2
46	Light Freezing Rain	-10	25	C I			2
47	Light Freezing Rain	-10	25	C I			2
48	Light Freezing Rain	-10	25	C I			2
49	Light Freezing Rain	-10	25	XL54 / 0 ETH			2
50	Light Freezing Rain	-10	25	XL54 / 0 ETH			2
51	Light Freezing Rain	-10	25	XL54 / 0 PRO			2
52	Light Freezing Rain	-10	25	XL54 / 0 PRO			2
53	Light Freezing Rain	-10	25	C I / 0 ETH			2
54	Light Freezing Rain	-10	25	C I / 0 ETH			2
55	Light Freezing Rain	-10	25	C I / 0 PRO			2
56	Light Freezing Rain	-10	25	C I / 0 PRO			2

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Total (min) = 7756

Total (hours) = 129

ATTACHMENT C-VII

NRC COLD CHAMBER TESTS MARCH 1998

TEST EQUIPMENT CHECKLIST

TASK	*NRC Cold Chamber*	
	Resp.	Status
Logistics for Every Test		
Make Hotel reservations		
Rent Van/Car		
Call Site Personnel		
Call RVSI Personnel		
Test Equipment		
Stand x 1		
C/FIMS (computers, cables, ...) x 3		
Laptop Computer		
Still Photo Camera		
Weigh Scale (backup)		
Video Camera x 2 (Surf & Snow) + Access.		
Reg. Plates (wing nuts) x 12+12		
Data Forms for plates	MC	
Precipitation rate Data Forms	MC	
Reports + Tables (Temperature conversion, Dilution, ..)		
Large Precipitation Pans x 36		
Type I Fluids		
Type II Fluids, Type IV Fluids		
Clipboards x 3		
Pencils + Space pens x 4		
Paper Towels		
Rubber squeegees		
Plastic refills for fluids and funnels		
Electrical Extension Cords		
Lighting x 2		
Stop watches x 4		
Storage bins for small equipment		
Protective clothing (2)		
Brixometer x 3		
Thermometers		
Tie wraps		
Funnels		
Temperature Probes		
Thickness Gauges		
Fluid Sampling Kit		
Scrapers		
Infra-red Thermometer		
Ice-Ex		
Watches		
Cooling Unit		
Cold-Soaked Boxes 7.5 cm x 6 cm		
Thermistor Kit + Logger		
Anemometer (hand-held)		
Inclinometer		
Fluid Spreaders		
lectric Stoves		
Double Boilers		
Test Procedures x 10		
Thermos Containers		
Wind Vane		
Printer (Brother)		
Washers		
Refrigerator		

ATTACHMENT C-VIII

AMENDED PROCEDURE FOR THE COLLECTION OF PRECIPITATION FOR HOLDOVER TIME TRIALS

The precipitation rate procedure outlined below is for use in 1998/99 holdover time trials. A concentrated effort has been made on an annual basis to improve this procedure based on the experiences gained though testing.

Below is an example of a typical test stand used for the conduct of holdover time tests. Each number represents a test location (plate location) on the test stand.

1	2	3	4	5	6
7	8	9	10	11	12

Prior to the start of the rate collection period, the proper needles and nozzles are installed in the spraying device, and the various pressure settings are adjusted. Water spray calibration is performed by placing catch pans on the test stand, each pan marked with a number identifying the collection location on the test stand, and exposing the pans to a predetermined collection period.

The pans are weighed prior to exposure to precipitation and the weights are recorded. Prior to the start of the precipitation catch period, the exact time (hh:mm:ss) is recorded. The pans are re-weighed following this period and the precipitation rates over the area of the test stand are examined. If the rates are unacceptable, re-calibration of the water spray is necessary. If the rates are deemed to be acceptable, the pans are weighed and placed on the stand for a second collection period. After the second collection period has expired, the pans are again re-weighed and the rates computed.

Once two rates have been collected at each test location, the catch rates of

the first and second collection are compared. If the average catch rate for any location is close to the precipitation rate required for the condition, then the pouring of fluids may begin at this location.
Rates will continuously be monitored at a minimum of two locations during a test in order to ensure there are no significant rate fluctuations. Pans will be placed at these locations and be re-weighed at fixed intervals (15 minutes, typically) during the course of a test. If a rate fluctuation occurs, the test is stopped.

Following the failure of a test plate, a rate collection pan is weighed and placed at the plate location for a predetermined time interval. It is then re-weighed and placed again on the stand in order to collect a minimum of two rates at this location.

The rate of precipitation for any location on the stand is calculated by averaging the two rates collected prior to the test and the two rates collected following the test.

The following is an example of a test run conducted in light freezing rain conditions. The desired rate of precipitation for this run is 25 g/dm^2/h.

Prior to the start of the test, collection pans are placed at each of the locations on the stand. Following a collection period, the pans are re-weighed. The following rates were recorded.

Rate collection #1

1 24.5 g/dm^2/h	2 24.6 g/dm^2/h	3 24.2 g/dm^2/h	4 23.9 g/dm^2/h	5 25.0 g/dm^2/h	6 26.4 g/dm^2/h
7 26.2 g/dm^2/h	8 25.6 g/dm^2/h	9 25.3 g/dm^2/h	10 25.1 g/dm^2/h	11 25.7 g/dm^2/h	12 26.1 g/dm^2/h

The rates are deemed to be acceptable, and therefore the pans are immediately returned to the test stand and a second rate collection period is initiated. Following the collection period, the pans are again re-weighed.

Rate collection #2

1 25.1 g/dm^2/h	2 24.8 g/dm^2/h	3 24.9 g/dm^2/h	4 25.9 g/dm^2/h	5 25.8 g/dm^2/h	6 25.4 g/dm^2/h
7 25.9 g/dm^2/h	8 25.3 g/dm^2/h	9 25.2 g/dm^2/h	10 25.0 g/dm^2/h	11 25.1 g/dm^2/h	12 26.4 g/dm^2/h

A calculation of the precipitation rates reveals that the rates are consistent As a result, holdover time tests will be conducted on plates 1, 2, 3, 4, 5, 6, 8, 9, 10 and 11. Collection pans will be re-weighed and placed on locations 7 and 12 in order to provide continuous monitoring of the rates during the test period.

Following the failure of the plates, the collection pans are weighed and once again placed on the test stand at their respective locations. Following the precipitation collection period, the pans are re-weighed.

Rate collection #3 (following plate failure)

1 25.4 g/dm^2/h	2 24.9 g/dm^2/h	3 25.5 g/dm^2/h	4 26.7 g/dm^2/h	5 25.2 g/dm^2/h	6 26.5 g/dm^2/h
7 26.3 g/dm^2/h	8 25.4 g/dm^2/h	9 24.6 g/dm^2/h	10 25.5 g/dm^2/h	11 24.3 g/dm^2/h	12 26.3 g/dm^2/h

The pans are returned to the stand. Following another collection period, they are re-weighed for the final time.

Rate collection #4 (following plate failure)

1 25.2 g/dm^2/h	2 25.7 g/dm^2/h	3 25.1 g/dm^2/h	4 24.3 g/dm^2/h	5 25.7 g/dm^2/h	6 26.9 g/dm^2/h
7 26.7 g/dm^2/h	8 25.4 g/dm^2/h	9 24.6 g/dm^2/h	10 25.5 g/dm^2/h	11 24.3 g/dm^2/h	12 26.3 g/dm^2/h

The rate of precipitation for any location on the stand may be calculated by averaging the four rates obtained for this location. Below are the calculated precipitation rates for the example run.

Average Precipitation Rates

1 25.1 g/dm^2/h	2 25.0 g/dm^2/h	3 24.9 g/dm^2/h	4 25.2 g/dm^2/h	5 25.4 g/dm^2/h	6 26.3 g/dm^2/h
7 26.3 g/dm^2/h	8 25.4 g/dm^2/h	9 24.9 g/dm^2/h	10 25.3 g/dm^2/h	11 24.9 g/dm^2/h	12 26.3 g/dm^2/h

The normal procedure is to conduct two tests at about 25 g/dm^2/h and two tests at about 13 g/dm^2/h for light freezing rain. Each of these tests are conducted at the same temperature (i.e. −3°C). The average values obtained for precipitation rate at each position is used for each test. The HOT value at the required precipitation rate (for example at 25 g/dm^2/h) is obtained by producing a "best fit" regression curve though the points using a "log-log" transformation based on the test points collected at around 13 g/dm^2/h and 25 g/dm^2/h. Similarly, the HOT value at 13 g/dm^2/h is obtained using the same curve.

ATTACHMENT R

APS RATE PROCEDURE FOR HOLDOVER TIME TESTING

Stand Calibration

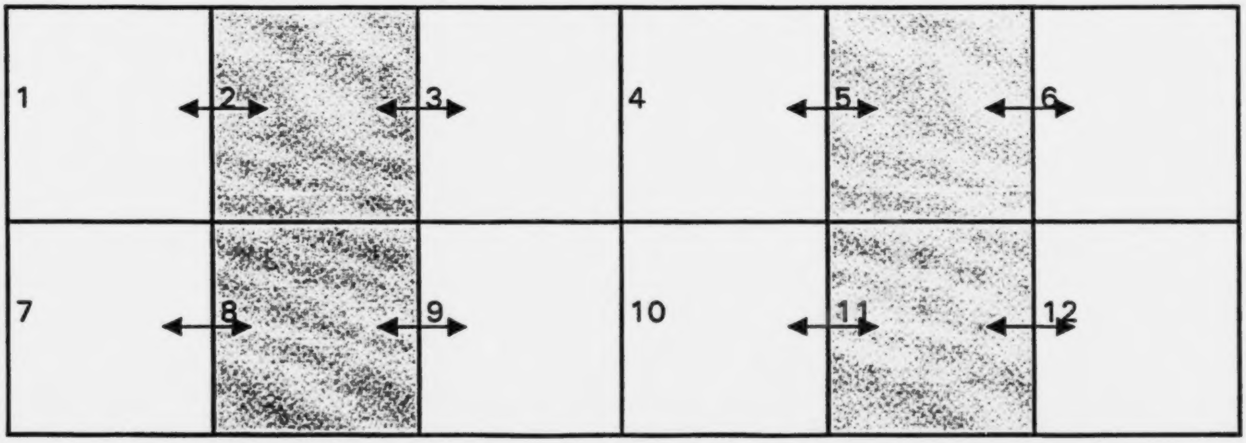
- Rate collection pans should be placed on all plate locations and allowed to collect precipitation for a predetermined time interval (5, 10, 15 minutes); following the precipitation collection period, the rates are calculated for each position.
- If results are acceptable (within tolerance levels), a second rate is collected at each position;
- If the results are again acceptable, the stand is considered calibrated. If the results are not acceptable, modifications to the set-up are made and the stand calibration is restarted.

Detailed Rate Distribution

- A detailed rate distribution will be measured by placing four equal size pans inside a standard rate pan and measuring the rate obtained in each of the smaller pans following exposure to freezing precipitation for a predetermined interval. The tolerances on the rate distribution pans will be double those used for standard rate calibration.
- Detailed rate distributions for constant monitoring and test positions will be randomly calculated, a minimum of once, each time the nozzle is changed or the pressure settings are modified.

Rate Procedure

- Once the stand calibration is complete and deemed satisfactory, a test may begin. Positions 2,5,8 and 11 (shaded area) are reserved for constant rate monitoring. Rates on these positions will be measured repeatedly every 15 minutes. No plate testing is permitted on these areas.
- Positions 1,3,4,6,7,9,10 and 12 are reserved for plate testing. Rates for any of these locations must be recorded twice before and after a test is performed.



- The constant rate monitoring positions are used to calculate ratios between the reference rates and adjacent positions. The ratio is then used to calculate the rate for any given position.

Example of Rate Calculation

Calculation of Rate of Precipitation for Position #1

Rate (Position #1)	**Ratio**	**Continuous Rate (Position #2)**
Rate Before **P1**	X	Continuous Rate Before **R1**
Rate Before **P2**		Continuous Rate Before **R2**
Run Test on Plate	Y	Continuous Rate During **Ra**
		Continuous Rate During **Rb**
		↓
		Continuous Rate During **Rn**
Rate After **P3**	Z	Continuous Rate After **R3**
Rate After **P4**		Continuous Rate After **R4**

$$\textbf{Ratio X} = \frac{\text{Avg (P1 + P2)}}{\text{Avg (R1 + R2)}}$$

$$\textbf{Ratio Z} = \frac{\text{Avg (P3 + P4)}}{\text{Avg (R3 + R4)}}$$

Ratio Y = Avg (Ratio X + Ratio Z)

Rate for Position #1 = Ratio Y x Avg (Ra + Rb + ... Rn)

Standard Deviation:

In order to obtain the standard deviation, the values **P1, P2, Calculated Rate, P4,** and **P5** are used.
The average rate and standard deviation must be within tolerances if test is to be acceptable.

ATTACHMENT T

Fluid Thickness Test Matrix

Run #	Fluid Manufac.	Fluid Dilution	Brand Name	Outside Air Temperature	Comments
1	Clariant	Neat (NS)	Safewing Four	-3	*Non-sheared*
2	Clariant	Neat (NS)	Safewing Four	-3	*Non-sheared*
3	Clariant	Neat	Safewing Four	-3	*Sheared*
4	Clariant	Neat	Safewing Four	-3	*Sheared*
5	Clariant	75/25	Safewing Four	-3	*Sheared*
6	Clariant	75/25	Safewing Four	-3	*Sheared*
7	Clariant	50/50	Safewing Four	-3	*Sheared*
8	Clariant	50/50	Safewing Four	-3	*Sheared*
9	Clariant	Neat (NS)	Safewing MP IV 1957	-3	*Non-sheared*
10	Clariant	Neat (NS)	Safewing MP IV 1957	-3	*Non-sheared*
11	Clariant	Neat	Safewing MP IV 1957	-3	*Sheared*
12	Clariant	Neat	Safewing MP IV 1957	-3	*Sheared*
13	Clariant	75/25	Safewing MP IV 1957	-3	*Sheared*
14	Clariant	75/25	Safewing MP IV 1957	-3	*Sheared*
15	Clariant	50/50	Safewing MP IV 1957	-3	*Sheared*
16	Clariant	50/50	Safewing MP IV 1957	-3	*Sheared*
17	Kilfrost	Neat (NS)	Kilfrost ABC 3+	-3	*Non-sheared*
18	Kilfrost	Neat (NS)	Kilfrost ABC 3+	-3	*Non-sheared*
19	Kilfrost	Neat	Kilfrost ABC 3+	-3	*Sheared*
20	Kilfrost	Neat	Kilfrost ABC 3+	-3	*Sheared*
21	Kilfrost	75/25	Kilfrost ABC 3+	-3	*Sheared*
22	Kilfrost	75/25	Kilfrost ABC 3+	-3	*Sheared*
23	Kilfrost	50/50	Kilfrost ABC 3+	-3	*Sheared*
24	Kilfrost	50/50	Kilfrost ABC 3+	-3	*Sheared*
25	Kilfrost	Neat (NS)	Kilfrost ABC S	-3	*Non-sheared*
26	Kilfrost	Neat (NS)	Kilfrost ABC S	-3	*Non-sheared*
27	Kilfrost	Neat	Kilfrost ABC S	-3	*Sheared*
28	Kilfrost	Neat	Kilfrost ABC S	-3	*Sheared*
29	Kilfrost	75/25	Kilfrost ABC S	-3	*Sheared*
30	Kilfrost	75/25	Kilfrost ABC S	-3	*Sheared*
31	Kilfrost	50/50	Kilfrost ABC S	-3	*Sheared*
32	Kilfrost	50/50	Kilfrost ABC S	-3	*Sheared*
33	Octagon	Neat	Maxflight	-3	*Sheared*
34	Octagon	Neat	Maxflight	-3	*Sheared*
35	Octagon	75/25	Maxflight	-3	*Sheared*
36	Octagon	75/25	Maxflight	-3	*Sheared*
37	Octagon	50/50	Maxflight	-3	*Sheared*
38	Octagon	50/50	Maxflight	-3	*Sheared*
39	Octagon	Neat (NS)	Maxflight	-3	*Non-sheared*
40	Octagon	Neat (NS)	Maxflight	-3	*Non-sheared*
41	Union Carbide	Neat	Ultra +	-3	*Sheared*
42	Union Carbide	Neat	Ultra +	-3	*Sheared*
43	Inland	Recycled Ethylene	3R-Duragly-E	-3	

Run #	Fluid Manufac.	Fluid Dilution	Brand Name	Outside Air Temperature	Comments
44	Inland	Recycled Ethylene	3R-Duragly-E	-3	
45	Inland	Recycled Propylene	3R-Duragly-P	-3	
46	Inland	Recycled Propylene	3R-Duragly-P	-3	
47	APS Aviation	Fluid X	I	-3	
48	APS Aviation	Fluid X	I	-3	

Notes:

- **NS: Non-Sheared**
- **If the results from the two tests for one fluid vary by more than 10% repeat the two tests and disreguard the highest and lowest values**
- **The quantity of fluid that will be poured for each test is 1.5 L**

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ATTACHMENT F

FROST TESTS (HOT)

PHASE I

PHASE II (PENDING)

FROST TEST (PHASE I)

Objective

Determine capability of creating frost on a constant temperature coldsoak box.

Personnel

One tester.

Procedure

- Set up constant temperature bath circulator (CTBC) and 2.5 cm coldsoak box;
- A flat plate is placed on the coldsoak box;
- Obtain OAT and RH. Use these values to determine frost point temperature;
- Set CTBC to frost point temperature and allow temperature in coldsoak box to stabilize;
- Measure rate of frost formation;
- Observe nature of frost formation ex. Crystal shape, destiny...;
- Record time necessary to cool coldsoak box; and
- Record time to first frost formation on coldsoak box.

Equipment

- Coldsoak box (2.5 cm);
- CTBC;
- Flat plate;
- Data forms (suggest note taking); and
- Relative humidity gauge.

ATTACHMENT Z

FREEZING FOG RESEARCH

PROCEDURE PENDING

- Verify rate of precipitation with new NRC spray set-up.
- Verify droplet size.
- Determine relative humidity.
- Determine area of concentration.
- Three people required (JD, MC, other.)
- ½ day should be allocated

ATTACHMENT M

MICROSCOPE RESEARCH

Objective

View and document, via the use of a microscope/stereoscope, precipitate crystal formation and suspension in/on de/anti-icing fluid during conditiond of freezing fog, freezing rain (high rates) and freezing dreizzle (low rate) at a temperature of -10°C.

Personnel

Two-person team (Elio, Melanie):

- First person, previous experience using a microscope obligatory;
- Second person, support duties, knowledge of microscope not essential.

Procedure

During any of the tests mentioned above, personnel will:

- Move in periodically (predetermined intervals during test) with microscope and attempt to view and document crystal formation on/in de/anti-icing fluid thickness;
- View different levels of fluid thickness, namely, top exposed surface, middle of thickness, and fluid/plate contact surface; and
- Attempt to visually characterize different crystal shapes and correlate them with the "subject evaluation" performed by Antoni Peters.

Equipment

- Microscope;
- Tripod stand for microscope;
- Data forms (suggest note taking); and
- Proper lighting.

APPENDIX D

TEST PROCEDURES – NRC JULY

CM1514.001

DETAILED PLAN OF NRC COLD CHAMBER TESTING

Summer 1999

- Freezing Fog
- Freezing Drizzle and Light Freezing Rain
- Rain on a Cold-Soaked Surface
- Simulated Snow

APS AVIATION INC.

July 1999
Version 1.0

DETAILED PLAN OF NATIONAL RESEARCH COUNCIL COLD CHAMBER TESTING

Winter 1998-99

This document provides the detailed procedures and equipment required for the conduct of simulated snow, freezing fog, freezing drizzle/rain and rain on a cold-soaked surface holdover time tests. These tests will be conducted at NRC's Climatic Engineering Facility (CEF) in Ottawa.

1. OBJECTIVES

The objective of the current holdover time test program is to establish holdover times for Type I over the full range of HOT table conditions. Scheduling of the indoor tests will be coordinated with the NRC. Duration of tests will be 7 working days, including set-up time. Fluid failure will be determined by visual observation.

The anticipated schedule of tests is also provided in this document.

2. PERSONNEL

An indication of the personnel required is provided below:

Failure:	Determine test fluids and positioning of tests on stand. Determine failure times.
Rate 1/2/3:	Measure precipitation rates.
Fluids	Measure Brix at pour; measure temperature at pour; prepare fluids for next tests.
Mgr/Data Entry:	Manage tests; enter data (rates and failure times) as collected. Ensure C/FIMS is functional.
Fluid Application:	Ensure plates are clean; application of fluids.

3. PROCEDURES

The following procedures have been included in this document:

- Holdover time procedures for indoor trials;
- Rate procedure for holdover time trials;
- Procedure for cold-soak box preparation; and
- NCAR snow generation system procedure.

4. TEST PLAN

The test schedule for CEF tests and the detailed test plan are included in this document.

5. EQUIPMENT

Test equipment required for the flat plate tests was determined from previous winters in association with the Society of Automotive Engineers (SAE) working group on ground deicing. A description of some important equipment appears in the indoor holdover time procedure document. The complete equipment list for CEF tests is shown in Attachment D-XI.

6. DATA FORMS

The data forms for tests conducted in simulated conditions are as follows:

- De/anti-icing data form for freezing precipitation, Attachment D-V;
- De/anti-icing data form for cold-soak box, Attachment D-VA;
- Precipitation rate measurement, Attachment D-VI;
- Detailed precipitation rate measurement form, Attachment D-VIIA;
- Continuous precipitation measurement form, Attachment D-VIIB; and
- Cold-soak precipitation rate measurement, Attachment D-VIII.

ATTACHMENT D-I
INDOOR FLAT PLATE TEST EQUIPMENT AND PROCEDURE
1998-99

This indoor test procedure has been developed based on discussions at the SAE G-12 Holdover Time Subcommittee working group on aircraft ground de/anti-icing as part of an overall testing program that includes laboratory tests, field tests and full-scale aircraft tests. The aim of this procedure is the development of holdover time table entries for freezing point depressant fluids known as de/anti-icing fluids.

1. SCOPE

This procedure describes the equipment and generalized steps to follow in order to standardize the method to be used to establish the time period for which freezing point depressant fluids provide protection to test panels during simulated winter conditions.

2. EQUIPMENT

The following equipment is required:

2.1 Plate Pans

Plate pans (27.7cm x 54cm), placed at a 10° inclination on the test stand, will be used to collect and weigh freezing precipitation. The procedure for the collection of precipitation rates using this method is described in Attachment D-V.

2.2 Temperature Gauge for Panels (optional)

Plate temperatures should be measured using thermocouples mounted directly underneath the test plate. All thermocouples are capable of measuring panel temperatures to an accuracy of 0.5°C (1°F) over the range +10°C to -30°C (+50°F to -20°F).

2.3 Test Stand

A typical test stand is illustrated in Appendix B; it may be altered to suit the location and facilities, but the angle for the panels, their arrangement and markings must all conform to Figures B-1A and B-2. There shall be no flanges or obstructions close to the edges of the panels that could interfere with the airflow over the panels. Test panels should be positioned on the test stand at a 10° ± 0.2° angle from the horizontal.

2.4 Test Panels

2.4.1 Material and Dimensions

Test panels are made of Alclad Aluminium, 2024-T6 or 5052-H32, polished standard roll mill finish. The test panel dimensions are 300 x 500 x 3.2 mm, with a working area of 250 x 450 mm. Thicker aluminium stock may be needed when an instrument is mounted on the plate (CFIMS Sensor required 6.4 mm). Typical plate roughness used in APS Holdover time trials is 0.4 microns, measured parallel to the long axis of the plate.

2.4.2 Markings

Each panel shall be marked (as shown in Figure B-2 of Appendix B) with lines at 25 and 150 mm from the panel top edge, with 15 crosshair points and with vertical lines 25 mm from each side; this marks off a working area of 250 x 450 mm on each panel. All marks shall be made using a 30 mm thick black marker or silk screen process, which does not come off with application of the test fluids or any of the cleaning agents. Re-marking of the plates will be required as the markings fade because of the cleaning actions.

2.4.3 Attachment of Test Panels

For attachment to the test stand, at least four holes shall be made, spaced along the two sides of each panel; the holes shall be within 20 mm (0.8") from the panel edge.

2.5 Fluid Application

The fluid should be poured onto the plates from a manageable container, until the entire test section surface is saturated and a consistent fluid thickness over the entire plate surface is obtained. For indoor tests at the National Research Council, about 1 litre of fluid per panel is sufficient.

2.6 Film Thickness Gauge

Film thickness at the 15 cm (6") line can be evaluated (this is optional). Painter's wet paint film thickness gauge. 1-08 mil gauge or equivalent is available from Paul N. Gardner Company Inc., Pompano Beach, Florida.

2.7 Video recording (optional)

Tests may also be recorded with a hand-held video camera, in particular at the start of the test and when failures are being called. Care must be taken that the camera and any lighting do not interfere with the airflow or ambient temperatures.

2.8 Relative Humidity Meter

Relative humidity in the test chamber will be recorded using a Vaisala RH Meter.

2.9 Ice Detection Sensors

Where feasible, surface or remotely mounted ice detection sensors should be used during the tests. Appendix B provides a description of the sensor equipment and sensor procedures.

2.10 Additional Equipment

- Squeegee/scraper
- Extension power cords
- Flood lights
- Watches/stopwatches

2.11 Test Chamber

Tests in simulated conditions will be conducted at the NRC, Climatic Engineering Facility in Ottawa. The chamber air temperature control is within 0.5°C based on the average air temperature measured at one-minute intervals. Temperature data is stored on the CEF data acquisition system. A minimum of thee thermocouples are mounted in close proximity to the test stands and are monitored thoughout the test set-up. The horizontal air velocity at the test stand is less than 1.0 m/s. The distance between nozzle and test plate is 6.5 to 6.7 meters, depending on the location of the plate on the test stand. The test chamber is equipped with artificial lighting, arranged such that it does not interfere with the precipitation or with the air, fluid and plate temperatures

2.12 Spray Equipment

2.12.1 Water supply

Water supply to the freezing rain scanner is well water from the NRC test site. An analysis of the water was completed in June of 1998.

2.12.2 Characteristics of Precipitation Produced

The following is a point-form summary of the set of test conditions under which data for freezing drizzle, light freezing rain, rain on a cold-soaked surface, and freezing fog are collected:

- Freezing Drizzle:
  High precipitation rate: 12.7g/dm²/h;
  Droplet median volume diameter: 350μm;
  Droplets produced with two #23 nozzles; and
  Air temperature: -3°C and −10°C.

  Low Precipitation rate: 5g/dm²/h;
  Droplet median volume diameter: 250μm;
  Droplets produced with two #24 nozzles; and
  Air temperature: -3°C and −10°C.

- Light Freezing Rain:
  High precipitation rate: 25g/dm²/h;
  Droplet median volume diameter: 1,000μm;
  Droplets produced with two #20 nozzles; and
  Air temperature: -3°C and −10°C.

  Low precipitation rate: 12.7g/dm²/h;
  Droplet median volume diameter: 1,000μm;
  Droplets produced with two #20 nozzles; and
  Air temperature: -3°C and −10°C.

- Drizzle on Cold-Soaked Surface:
  Precipitation rate: 5g/dm²/h;
  Droplet median volume diameter: 250μm;
  Droplets produced with two #24 nozzles; and
  Air temperature: +1°C.

- Moderate Rain on Cold-Soaked Surface:
  Precipitation rate: 76g/dm²/h;
  Droplet median volume diameter: 1,400μm;
  Droplets produced with two #17 nozzles; and
  Air temperature: +1°C.

- Freezing Fog:
  Precipitation rate: 2and 5g/dm²/h;
  Droplet median volume diameter: 30μm; and
  Air temperature: -3°C, -14°C and -25°C.

2.12.3 Droplet Size Determination

The droplet size determination and distribution can be determined using the Dye Stain Method. The Dye Stain Method technique consists of dusting filter paper disks with a water activated, very finely divided, powder form of methylene blue dye. The prepared disks are manually positioned under precipitation for a fixed time in order to acquire a droplet size pattern. A calibration curve is then used to convert from the measured diameter of the droplets ton the pattern to the experimental median volume diameter. This method of droplet size determination has been used for several years (see Transport Canada Reports TP 12654E, TP 12896E, TP 13131E, TP 13318E).

2.12.4 Distribution

The water spray shall be evenly distributed over the entire area of each test plate. Even distribution is verified by exposing either a clean test plate or sheet of paper briefly to the spray. Drop distribution on the plate or paper is visually evaluated. Uneven distribution requires that the spray equipment be adjusted (step size and spray head speed) until even distribution is achieved.

2.12.5 Spray Equipment

The nozzles used for the freezing rain and freezing drizzle are of an external mix, air-atomizing type. This type of nozzle arrangement allows for more control of air and water pressures at the nozzle to obtain correct drop sizes. The spray head is designed to have air under pressure impinge on the water stream leaving the nozzles (at a 7° angle in the NRC device). Nozzles are easily interchangeable though use of a positive twist lock fastening system, allowing for varying the nozzle diameter to achieve the required drop sizes. The number of nozzles can also be changed easily from 2 to 4 to permit an approximate doubling of rates delivered. This facilitates testing at different rate conditions. The sprayer head is driven in two axes by two independent stepper motors and controllers. By varying the motor speeds and step sizes the spray pattern can be set up to deliver uniform rates over given test areas. Thus the key control parameters to run a test are motor speed and step arrangement, nozzle size and number, water pressure and flow rate, and air pressure.

2.13 Calibration of Test Equipment

All temperature sensors, humidity sensors, electronic balances, anemometers, and timing devices shall be maintained in a known state of calibration. Experience indicates that a one-year calibration interval is sufficient.

3. DE/ANTI-ICING FLUIDS

3.1 Test Fluids

Only fluids that have been certified will be included in tests. Fluid suppliers shall submit to the test coordinating organization proof of certification for the fluids they provide.

3.2 Certification

Type IV fluids shall be pre-sheared by each manufacturer. Each manufacturer shall provide samples and a certificate of compliance showing the viscosity of their test sample of fluid before and after shearing, as well as information pertaining to the freeze point and refractive index of the fluid and other fluid parameters as usually provided to the end users. Viscosity and refractive index verifications of each fluid may be made by the test organization upon receipt of fluid from the manufacturer.

3.3 Fluid Dye

Fluids should be supplied for certification and for holdover time testing in the form to be used on aircraft.

4. PROCEDURE

4.1 Rate Procedure

The procedure for rate calculation is shown in Section 6.

4.2 Test Panel Preparation

4.2.1

Before the start of each day's testing, ensure the panels are clean using the procedure outlined in 4.3.2.

4.2.2

Place the panels on the fixture and attach to the frame screws with flat bolts (wing nuts will make attaching and removal easier in poor weather).

4.2.3

Allow the panels to cool to chamber temperature. The temperature may be verified using the thermistors attached to each plate.

4.3 Fluid Preparation and Application

Procedure for Type I Fluid Application

- Position plate covers over plates to protect from precipitation;
- Prepare 1 litre of test fluid and place it in a premarked pitcher. Fluid temperature must be 20°C ± 3°C. Measure and record Brix;
- Scrape up and squeege any ice off the plate;
- Apply 1/3 litre to fully cleanse the plate and squeege; and
- Apply remaining 2/3 litre on plate for test. Application should be consistent for each test to ensure consistent heat transfer to the plate,

4.3.1 Fluid Temperature

Except for Type I fluids, all fluids should be cold-soaked to ambient temperature conditions prior to the start of the test session.

4.3.2 Cleaning Panels

The test panels must be clean of all contamination prior to the start of any test. This is accomplished by scrapping off contamination, or when a different type of fluid is to be tested, a hot water wash is used to remove traces of the previous fluid. Before applying test fluid to any test panel, apply a small quantity of the fluid being used for the test and spread it over the entire test surface. Squeegee off any remaining fluid from the plate surface prior to the start of the test. Fluid for test is applied following procedure outlined in 4.3.3.

4.3.3 Fluid Application

Apply the fluids at chamber ambient test temperature ±1.0°C to the panels, commencing at the upper edge of the test panel and working downwards to the lower edge. Ensure complete and consistent coverage by applying the fluid in a flooding manner (1 litre of fluid should suffice). Start time of the test begins immediately following completion of the fluid application.

4.4 Holdover Time Testing

4.4.1

Record the elapsed time (holdover time) required for the fluid to achieve the test END CONDITION. See Section 5 for definition of end condition.

4.5 Video Recording (not performed routinely)

Video record test (if required) with a hand-held camera in the following sequences:

1) General laboratory conditions prior to test.
2) Video record the data forms.
3) Video record pouring. Ensure that name of fluids are captured, testers faces, your voice, name and stand # (ensure date and time are available and synchonized).
4) Record pans being weighed and brought out.
5) Record establishing shot of test stand (all the plates).
6) Record establishing shot of each plate, followed by a close-up of the plate (scan the plate slowly), then return to a wide shot of the plate. Repeat this with each plate in sequence . Record the clock/timer often.
7) For each failure, record an overview of the plates, followed by a wide shot of the plate, zooming into a close-up of the failure. Return to the establishing shot at the end of the procedure. Repeat this procedure for each failure.
8) Ensure that the lighting is appropriate for video purposes.
9) Ensure that the video camera is in fact recording. At the end of a test, rewind a few seconds and check that the test was recorded.

5. END CONDITION

The plate failure time is that time required for the end conditions to be achieved. This occurs when precipitation fails to be absorbed at any five of the crosshair marks on the panels or when 1/3 of the test panel is covered with accumulating precipitation.

A crosshair is considered failed if:

- There is a visible accumulation of snow (not slush, but white snow) on the fluid at the crosshair when viewed from the front (i.e. perpendicular to the plate). You are looking for an indication that the fluid can no longer accommodate or absorb the precipitation at this point.

OR

- When precipitation or frosting produces a loss of gloss (i.e. a dulling of the surface reflectivity) or a change in colour (dye) to gray or grayish appearance at any five crosshairs (or 1/3 of the plate area), or ice (or crusty snow) has formed (look for ice crystals). This condition is only applicable during freezing rain/drizzle, ice pellets, freezing fog or during a mixture of snow and freezing rain/drizzle and ice pellets.

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ATTACHMENT D-II

COLLECTION OF PRECIPITATION FOR HOLDOVER TIME TRIALS

AMENDED PROCEDURE FOR THE COLLECTION OF PRECIPITATION FOR HOLDOVER TIME TRIALS

The precipitation rate procedure outlined below is for use in 1997-98 holdover time trials. A concentrated effort has been made on an annual basis to improve this procedure based on the experiences gained though testing.

Below is an example of a typical test stand used for the conduct of holdover time tests. Each number represents a test location (plate location) on the test stand.

1	2	3	4	5	6
7	8	9	10	11	12

Prior to the start of the rate collection period, the proper needles and nozzles are installed in the spraying device, and the various pressure settings are adjusted. Water spray calibration is performed by placing catch pans on the test stand, each pan marked with a number identifying the collection location on the test stand, and exposing the pans to a predetermined collection period.

The pans are weighed prior to exposure to precipitation and the weights are recorded. Prior to the start of the precipitation catch period, the exact time (hh:mm:ss) is recorded. The pans are re-weighed following this period and the precipitation rates over the area of the test stand are examined. If the rates are unacceptable, re-calibration of the water spray is necessary. If the rates are deemed to be acceptable, the pans are weighed and placed on the stand for a second collection period. After the second collection period has expired, the pans are again re-weighed and the rates computed.

Once two rates have been collected at each test location, the catch rates of the first and second collection are compared. If the average catch rate for any location is close to the precipitation rate required for the condition, then the pouring of fluids may begin at this location.

Rates will continuously be monitored at a minimum of two locations during a test in order to ensure there are no significant rate fluctuations. Pans will be placed at these locations and be re-weighed at fixed intervals (15 minutes, typically) during the course of a test. If a rate fluctuation occurs, the test is stopped.

Following the failure of a test plate, a rate collection pan is weighed and placed at the plate location for a predetermined time interval. It is then re-weighed and placed again on the stand in order to collect a minimum of two rates at this location.

The rate of precipitation for any location on the stand is calculated by averaging the two rates collected prior to the test and the two rates collected following the test.

The following is an example of a test run conducted in light freezing rain conditions. The desired rate of precipitation for this run is 25 g/dm^2/h.

Prior to the start of the test, collection pans are placed at each of the locations on the stand. Following a collection period, the pans are re-weighed. The following rates were recorded.

Rate collection #1

1 24.5 g/dm^2/h	2 24.6 g/dm^2/h	3 24.2 g/dm^2/h	4 23.9 g/dm^2/h	5 25.0 g/dm^2/h	6 26.4 g/dm^2/h
7 26.2 g/dm^2/h	8 25.6 g/dm^2/h	9 25.3 g/dm^2/h	10 25.1 g/dm^2/h	11 25.7 g/dm^2/h	12 26.1 g/dm^2/h

The rates are deemed to be acceptable, and therefore the pans are immediately returned to the test stand and a second rate collection period is initiated. Following the collection period, the pans are again re-weighed.

Rate collection #2

1 25.1 g/dm^2/h	2 24.8 g/dm^2/h	3 24.9 g/dm^2/h	4 25.9 g/dm^2/h	5 25.8 g/dm^2/h	6 25.4 g/dm^2/h
7 25.9 g/dm^2/h	8 25.3 g/dm^2/h	9 25.2 g/dm^2/h	10 25.0 g/dm^2/h	11 25.1 g/dm^2/h	12 26.4 g/dm^2/h

A calculation of the precipitation rates reveals that the rates are consistent As a result, holdover time tests will be conducted on plates 1, 2, 3, 4, 5, 6, 8, 9, 10 and 11. Collection pans will be re-weighed and placed on locations 7 and 12 in order to provide continuous monitoring of the rates during the test period.

Following the failure of the plates, the collection pans are weighed and once again placed on the test stand at their respective locations. Following the precipitation collection period, the pans are re-weighed.

Rate collection #3 (following plate failure)

1 25.4 g/dm^2/h	2 24.9 g/dm^2/h	3 25.5 g/dm^2/h	4 26.7 g/dm^2/h	5 25.2 g/dm^2/h	6 26.5 g/dm^2/h
7 26.3 g/dm^2/h	8 25.4 g/dm^2/h	9 24.6 g/dm^2/h	10 25.5 g/dm^2/h	11 24.3 g/dm^2/h	12 26.3 g/dm^2/h

The pans are returned to the stand. Following another collection period, they are re-weighed for the final time.

Rate collection #4 (following plate failure)

1 25.2 g/dm^2/h	2 25.7 g/dm^2/h	3 25.1 g/dm^2/h	4 24.3 g/dm^2/h	5 25.7 g/dm^2/h	6 26.9 g/dm^2/h
7 26.7 g/dm^2/h	8 25.4 g/dm^2/h	9 24.6 g/dm^2/h	10 25.5 g/dm^2/h	11 24.3 g/dm^2/h	12 26.3 g/dm^2/h

The rate of precipitation for any location on the stand may be calculated by averaging the four rates obtained for this location. Below are the calculated precipitation rates for the example run.

Average Precipitation Rates

1 25.1 g/dm^2/h	2 25.0 g/dm^2/h	3 24.9 g/dm^2/h	4 25.2 g/dm^2/h	5 25.4 g/dm^2/h	6 26.3 g/dm^2/h
7 26.3 g/dm^2/h	8 25.4 g/dm^2/h	9 24.9 g/dm^2/h	10 25.3 g/dm^2/h	11 24.9 g/dm^2/h	12 26.3 g/dm^2/h

The normal procedure is to conduct two tests at about 25 g/dm^2/h and two tests at about 13 g/dm^2/h for light freezing rain. Each of these tests are conducted at the same temperature (i.e. –3°C). The average values obtained for precipitation rate at each position is used for each test. The HOT value at the required precipitation rate (for example at 25 g/dm^2/h) is obtained by producing a "best fit" regression curve though the points using a "log-log" transformation based on the test points collected at around 13 g/dm^2/h and 25 g/dm^2/h. Similarly, the HOT value at 13 g/dm^2/h is obtained using the same curve. This method is repeated for all other conditions and associated temperatures described in 2.12.2., for each fluid.

ATTACHMENT D-III

SAMPLE SELECTION PROCEDURE FOR ENDURANCE TIME TESTING FOR FLUIDS MEETING THE REQUIREMENTS OF SAE AMS 1424

[This version includes explanatory annotations]

1. Purpose

1.1 For the purpose of validation by the SAE G-12 Holdovertime Subcommittee that a fluid can be used with the generic SAE type I holdovertime guidelines, the fluid manufacturer shall send a sample of its fluid to the appropriate designated testing agent(s) for endurance time testing.

1.2 The testing agent(s) shall be designated by the Chairs of the SAE G-12 Holdovertime Subcommittee.

[The SAE Fluids Subcommittee and the SAE Holdovertime Subcommittee did not have the authority to impose the task of selecting testing agents to the Regulatory Authorities. Since the endurance time test results will be perused by the Holdovertime Subcommittee, it seemed logical to have the Chairs of that Subcommittee designate appropriate testing agent(s). The current Co-chairs (who are both employed by Regulatory Authorities) agreed to do so.]

2. Requirements

2.1 The sample shall be a fluid taken from a production batch (in a form normally supplied by the vendor).

2.2 If the (ready-to-use) fluid is intended for use undiluted, the WSET of the sheared and unsheared sample must not be less than 3 minutes.

[The reason for the sheared sample is that the normal certification process calls for the fluid to be sheared, since all parties want to make sure that the sample is representative of the certification, the WSET must be run sheared. Since the endurance time testing will be done by the laboratory without further shearing, the unsheared sample must also perform satisfactorily, thus the requirement for the unsheared WSET.]

2.3 If the fluid (concentrate) is intended for use diluted, the WSET of a sheared and unsheared 50/50 volume ratio of sample and hard water (defined in paragraph 3.3.3.1 of AMS 1424) must not be less than 3 minutes.

[Paragraph 3.3.3.1 specifies the use of calcium acetate dihydrate, $Ca(C_2H_3O_2)_2.2H_2O$*, as the source of* Ca^{++}*. However, calcium acetate dihydrate is not readily available. More often calcium acetate monohydrate or anhydrous calcium acetate are used. Therefore, laboratories should titrate the hard water to make sure it has 82.6 mg/L* Ca^{++}*. Source J.-L. Laforte.]*

2.4 The fluid manufacturer shall send to the designated testing agent

2.4.1 the SAE AMS 1424 certificates of conformance of the fluid (to ensure the fluid is fully certified);

2.4.2 the volume dilution vs. freezing point data for the fluid (data needed to prepare the dilutions);

2.4.3 the freezing point vs. refraction at 20°C data for the fluid (to check the correctness of dilutions).

2.5 If the fluid is intended for use undiluted, the designated testing facilities shall
—run a WSET on the sheared sample;

—run a WSET on the unsheared sample;

—report the results to the manufacturer prior to running any endurance time testing.

2.6 If the fluid is intended for use diluted, the designated testing facilities shall
—dilute the sample 50/50 by volume with hard water (defined in paragraph 3.3.3.1 of AMS 1424);

—run WSET on this diluted sample unsheared;

—run WSET on this diluted sample sheared;

—report the results to the manufacturer prior to running any endurance time testing.

3. Authorization to Proceed with Endurance Time Testing

3.1 The designated testing agent shall make sure that it has on hand items described in 2.4.1, 2.4.2, and 2.4.3.

3.2 The designated testing agent shall make sure that the WSETs measured in 2.5 or 2.6 are not less than 3 minutes.

3.3 After reviewing the results of 2.5 or 2.6, the manufacturer must send to the designated testing agent authorization to proceed with endurance time testing.

3.4 The designated testing agent shall proceed with endurance time testing upon successful completion of 3.1 and 3.2. and 3.3.

[Note that, according to the resolutions of the SAE G-12 Fluids Subcommittee, for fluids to be tested between 28 May 1999 until 1 November 1999, such fluids need to be tested by both the APS/NCAR and Montreal protocols. It was also a resolution of the Subcommittee for such samples to be tested in natural snow for comparison purposes. Therefore the designated testing agent will need to

—make sure it receives enough sample;

—send a portion to a certified lab (presumably AMIL) for WSET testing (as required by 2.5 or 2.6);

—send a portion of the sample to APS for the APS/NCAR protocol testing;

—send a portion to AMIL for the Montreal protocol testing;

—keep a portion for the outside snow testing of 1999–2000.

Remember that the Chairs of the SAE G-12 Holdovertime Subcommittee will submit the data generated by the APS/NCAR protocols and the Montreal protocols to members of the SAE G-12 Holdovertime Subcommittee when available. Presumably the natural snow data will be presented after the 1999–2000 winter.]

4.Endurance Time Testing

4.1 The sample shall be tested at dilutions where the freezing point is 10°C below the test temperature. The dilutions shall be prepared by the designated testing facilities using hard water (defined in paragraph 3.3.3.1 of AMS 1424).

[The sample here is the one shipped to the designated testing agent and described in 2.1. This sample is from a production batch, in a form as it is normally sold. This sample is not sheared by the manufacturer and will not be sheared by the testing laboratory for the endurance time tests.]

[Since the testing temperature range is extremely wide, the sample will actually be tested over a wide range of concentrations including the much used 50/50 dilution—it is therefore not necessary to run separate tests on the 50/50 dilution. When testing the very low temperatures for fluid concentrates, the dilution will cover the highest glycol concentrations allowable under the aerodynamic acceptance test. Therefore testing fluid with freezing point 10°C below the test temperatures will ensure that the fluid is tested from very diluted to its maximum allowable concentration]

4.2 Test temperatures shall not be lower than the lowest acceptable aerodynamic performance in accordance with Annex B of 3.5.3 of SAE AMS 1424 as reported in the certificate of conformance provided to the designated testing agent under 2.4.1 of this procedure.

[Paragraph 4.2 is required because there is no reason to test below the lowest aerodynamic acceptance for the fluid. Appendix B was chosen because the acceptable temperature will be lower than under Annex C. The fluid must be tested at the lowest aerodynamic acceptable temperature.]

Abbreviations

AMS	Aerospace Material Specification
FAA	Federal Aviation Administration
SAE	Society of Automotive Engineers
WSET	Water Spray Endurance Time

[My comments are in square brackets and try provide explanations.]—J. Leroux

ATTACHMENT D-IV

PROCEDURE FOR CSW BOX PREPARATION

1) Place cover and insulation;
2) Measure rates while cooling box to -11.5°C ± 1.0°C;
3) Remove insulation but keep cover;
4) Allow to warm to -10°C ± 0.5°C;
5) Start test;
6) Place cover and insulation at end of test; and
7) Measure rates while re-cooling box to -11.5°C ± 1.0°C.

A typical box can be in one of the following stages. This sequencing is as shown here:
1) Not used or waiting to be cooled; 2) Cooling to -11.5°C; 3) Warming to -10°C; and 4) Test.

When ready for use and to be cooled, fill in table below to monitor situation.

Box Position	Circle when condition starts and strike out when condition is complete			Comments
	Cooling	Warming	Test	
	Cooling	Warming	Test	
	Cooling	Warming	Test	
	Cooling	Warming	Test	
	Cooling	Warming	Test	
	Cooling	Warming	Test	
	Cooling	Warming	Test	
	Cooling	Warming	Test	
	Cooling	Warming	Test	
	Cooling	Warming	Test	
	Cooling	Warming	Test	
	Cooling	Warming	Test	
	Cooling	Warming	Test	
	Cooling	Warming	Test	
	Cooling	Warming	Test	
	Cooling	Warming	Test	
	Cooling	Warming	Test	
	Cooling	Warming	Test	
	Cooling	Warming	Test	
	Cooling	Warming	Test	
	Cooling	Warming	Test	
	Cooling	Warming	Test	
	Cooling	Warming	Test	

ATTACHMENT D-V

DE/ANTI-ICING DATA FORM FOR FREEZING PRECIPITATION

REMEMBER TO SYNCHRONIZE TIME

VERSION 5.0

1997/98

LOCATION: CEF (Ottawa) **DATE:** **RUN NUMBER:** **STAND # :**

TIME TO FAILURE FOR INDIVIDUAL CROSSHAIRS (real time)

Time of Fluid Application:	______	______	______	______	______	______
Initial Brix	______	______	______	______	______	______
Initial Fluid Temperatrure	______	______	______	______	______	______

	Plate 1	**Plate 2**	**Plate 3**	**Plate 4**	**Plate 5**	**Plate 6**
FLUID NAME/BATCH						
B1 B2 B3						
C1 C2 C3						
D1 D2 D3						
E1 E2 E3						
F1 F2 F3						
TIME TO FIRST PLATE FAILURE WITHIN WORK AREA						
FAILURE CALL	V. Difficult Difficult. Easy	V. Difficult Difficult. Easy	V. Difficult Difficult. Easy	V. Difficult Difficult. Easy	V. Difficult Difficult. Easy	V. Difficult Difficult. Easy
C/FIMS						

Time of Fluid Application:	______	______	______	______	______	______
Initial Brix	______	______	______	______	______	______
Initial Fluid Temperatrure	______	______	______	______	______	______

	Plate 7	**Plate 8**	**Plate 9**	**Plate 10**	**Plate 11**	**Plate 12**
FLUID NAME/BATCH						
B1 B2 B3						
C1 C2 C3						
D1 D2 D3						
E1 E2 E3						
F1 F2 F3						
TIME TO FIRST PLATE FAILURE WITHIN WORK AREA						
FAILURE CALL	V. Difficult Difficult. Easy	V. Difficult Difficult. Easy	V. Difficult Difficult. Easy	V. Difficult Difficult. Easy	V. Difficult Difficult. Easy	V. Difficult Difficult. Easy
C/FIMS						

PRECIP: ZF , ZD , ZR-, MOD

AMBIENT TEMPERATURE: ________ °C

COMMENTS: ______________________________

____

____

FAILURES CALLED BY : ______________________

HAND WRITTTEN BY : ______________________

LEADER: ______________________

ATTACHMENT D-VA

DE/ANTI-ICING DATA FORM FOR COLD SOAK BOX

REMEMBER TO SYNCHRONIZE TIME

LOCATION: CEF (Ottawa) **DATE:** **RUN NUMBER:** **STAND # :**

TIME TO FAILURE FOR INDIVIDUAL CROSSHAIRS (real time)

Time of Fluid Application					
Initial Brix					
Fluid Temperature					
Intial Box Temperature					
Enter Box Number	Box #	Box #	Box #	Box #	Box #
FLUID NAME/BATCH					
B1 B2 B3					
C1 C2 C3					
D1 D2 D3					
E1 E2 E3					
F1 F2 F3					
TIME TO FIRST PLATE FAILURE WITHIN WORK AREA					
FAILURE CALL	V. Difficult Difficult. Easy	V. Difficult Difficult. Easy	V. Difficult Difficult. Easy	V. Difficult Difficult. Easy	V. Difficult Difficult. Easy
Final Box Temperature					

Time of Fluid Application					
Initial Brix					
Fluid Temperature					
Intial Box Temperature					
Enter Box Number	Box #	Box #	Box #	Box #	Box #
FLUID NAME/BATCH					
B1 B2 B3					
C1 C2 C3					
D1 D2 D3					
E1 E2 E3					
F1 F2 F3					
TIME TO FIRST PLATE FAILURE WITHIN WORK AREA					
FAILURE CALL	V. Difficult Difficult. Easy	V. Difficult Difficult. Easy	V. Difficult Difficult. Easy	V. Difficult Difficult. Easy	V. Difficult Difficult. Easy
Final Box Temperature					

AMBIENT TEMPERATURE: ________ °C

COMMENTS:

FAILURES CALLED BY :

HAND WRITTTEN BY :

* To Compare to previous years of testing, subtract "Time of Fluid Aplication".

ATTACHMENT D-VI

PRECIPITATION RATE MEASUREMENT AT CEF IN OTTAWA

Date: ____________________

Start Time: ____________________

Run # : ____________________

Stand: ____________________

Precip Type: ____________________ (ZD, ZR-, FZF, S)

Needles used: __________

Flow Rate of Water: __________

Line Air Pressure: __________

Line Air Temperature: __________

Line Water Pressure: __________

Line Water Temperature: __________

Pan Location:

1	2	3	4	5	6
7	8	9	10	11	12

Collection Pan:

Pan #	Area of Pan (dm^2)	Location	Weight of Pan (g)		Collection Time (hr:mm:ss)		Rate
			Before	After	Start	End	
1	14.90	1					
2	14.90	2					
3	14.90	3					
4	14.90	4					
5	14.90	5					
6	14.90	6					
7	14.90	7					
8	14.90	8					
9	14.90	9					
10	14.90	10					
11	14.90	11					
12	14.90	12					
13	14.90	13					
14	14.90	14					
15	14.90	15					
16	14.90	16					

Comments: ____

Handwritten by: ____________________

Measured by: ____________________

Precipitation Rate = $\Delta g/\text{area } (dm^2)/hr$

ATTACHMENT D-VIIA
DETAILED PRECIPITATION RATE MEASUREMENT AT CEF IN OTTAWA

PLATE

1	2
3	4

Date: ______________

Start Time: ______________

Run # : ______________

Stand: ______________

Precip Type: ______________ (ZD, ZR-)

Pan Location (Circle):

1	2	3	4	5	6
7	8	9	10	11	12

Collection Pan:

Pan/	Area of	Weight of Pan (g)		Collection Time (hr:mm:ss)		Rate
#	Pan (dm²)	Before	After	Start	End	
1						
2						
3						
4						

Comments:

Handwritten by: ______________

Measured by: ______________

Precipitation Rate = Δg/area (dm²)/hr

ATTACHMENT D-VIIB

CONTINUOUS PRECIPITATION RATE MEASUREMENT AT CEF IN OTTAWA

Date: ____________________

Start Time: ____________________

Run # : ____________________

Stand: ____________________

Precip Type: ____________________ (ZD, ZR-, FZF, S, CS)

Pan Location:

1	2	3	4	5	6
7	8	9	10	11	12

Collection Pan:

Pan #	Area of Pan (dm^2)	Location	Weight of Pan (g)		Collection Time (hr:mm:ss)		Rate
			Before	After	Start	End	
1	14.90						
2							
1							
2							
1							
2							
1							
2							
1							
2							
1							
2							
1							
2							
1							
2							
1							
2							
1							
2							

Comments: ____

Handwritten by: ____________________

Measured by: ____________________

Precipitation Rate = Δg/area (dm^2)/hr

ATTACHMENT D-VIII

COLD SOAK PRECIPITATION RATE MEASUREMENT AT CEF IN OTTAWA

Date: ____________________

Start Time: ____________________

Run # : ____________________

Precip Type: ____________________ (Drizzle, Light Rain, Moderate Rain, Heavy Rain)

Pan Location:

1	2	3	4	5
6	7	8	9	10

Collection Pan:

Pan #	Area of Pan (dm²)	Location		Weight of Pan (g)		Collection Time (hr:mm:ss)		RATE
				Before	After	Start	End	
1	14.90	1	=					
2	14.90	2	=					
3	14.90	3	=					
4	14.90	4	=					
5	14.90	5	=					
6	14.90	6	=					
7	14.90	7	=					
8	14.90	8	=					
9	14.90	9	=					
10	14.90	10	=					

Comments: ____

____

____

____

Handwritten by: ____________________

Measured by: ____________________

Precipitation Rate = Δg/area (dm^2)/hr

ATTACHMENT D-IX
TEST SCHEDULE

July 19, 1999
Monday

MC, ER, MH, OW1

7^{AM}	
8^{00}	SETUP
9^{00}	
	RATES ZD -10, 5
10^{00}	
11^{00}	TESTS
12^{PM}	RATE
	CHANGEOVER
1^{00}	RATES ZD -10, 13
2^{00}	
	TESTS
3^{00}	
	RATE
4^{00}	
5^{00}	
6^{00}	

July 20, 1999
TUESDAY

MC, ER, MH, OW1

7^{AM}	
8^{00}	STARTUP
9^{00}	
	RATES ZR -10, 13
10^{00}	
	TESTS
11^{00}	RATES
	CHANGEOVER
12^{PM}	RATES ZR -10, 25
1^{00}	
	TESTS
2^{00}	RATES
3^{00}	
4^{00}	
5^{00}	
6^{00}	

July 21, 1999
WEDNESDAY

MC, ER, MH, OW1

7^{AM}	
8^{00}	STARTUP
9^{00}	RATES ZD -10, 5
10^{00}	
11^{00}	TESTS
12^{PM}	RATES
	CHANGEOVER
1^{00}	RATES ZFOG -10, 5
2^{00}	
3^{00}	TESTS
4^{00}	RATE
5^{00}	
6^{00}	

July 22, 1999
THURSDAY

MC, ER, MH, OW1

7^{AM}	
8^{00}	STARTUP
9^{00}	RATES 1 ZFOG; LOUT; 2 g/dm^2/hr
10^{00}	
11^{00}	TEST 1
	RATES 1
12^{PM}	TEMP CHANGE
	RATE 2
1^{00}	
	TEST 2
2^{00}	RATE 2
	TEMP CHANGE
3^{00}	RATE 3
4^{00}	TEST 3
	RATE 3
5^{00}	TEMP CHANGE
	RATE 4
6^{00}	
	TEST 4

7:00pm - 7:30pm RATE 4

July 23, 1999
FRIDAY

MC, ER, MH, OW1

7^{AM}	
8^{00}	STARTUP
9^{00}	RATES 1 ZFOG; LOUT; 2
10^{00}	
11^{00}	TEST 1
	RATES 1
12^{PM}	TEMP CHANGE
	RATE 2 ZFOG; LOUT, 5
1^{00}	
	TEST 2
2^{00}	RATE 2
	TEMP CHANGE
3^{00}	RATE 3
4^{00}	TEST 3
	RATE 3
5^{00}	TEMP CHANGE
	RATE 4
6^{00}	
	TEST 4

7:pm - 7:30pm RATE 4

July 24, 1999
SATURDAY

MC, ER, MH, OW1

7^{AM}	
8^{00}	STARTUP
9^{00}	
	RATES CSW; +1, 5
10^{00}	
	TESTS
11^{00}	
	RATES
12^{PM}	CHANGEOVER
	RATES CSW; +1, 75
1^{00}	
2^{00}	TESTS
3^{00}	RATES
4^{00}	
5^{00}	
6^{00}	

July 19, 1999
Monday

HUNT OR SHERRI

7^{AM}	
8^{00}	SETUP NCAR
9^{00}	
10^{00}	
11^{00}	TESTS
12^{PM}	RATE
	CHANGEOVER TEST 1, 17
1^{00}	3, 19
2^{00}	5, 21
3^{00}	7, 23
	RATE
4^{00}	
5^{00}	
6^{00}	

July 20, 1999
TUESDAY

HUNT OR SHERRI

7^{AM}		
8^{00}	STARTUP	
9^{00}	RATES ZR-, -10,13	9, 25
		11,27
10^{00}		
	TESTS	13, 29
11^{00}	RATE	
	CHANGEOVER	15, 31
12^{PM}	RATES ZR-, -10, 25	2, 18
1^{00}		4, 20
	TESTS	6, 22
2^{00}	RATES	
3^{00}		
4^{00}		
5^{00}		
6^{00}		

July 21, 1999
WEDNESDAY

HUNT OR SHERRI

7^{AM}		
8^{00}	STARTUP	
9^{00}	RATES ZFOG-10, 2	8, 24
10^{00}		10, 26
		12, 28
11^{00}	TESTS	
		14, 30
12^{PM}	RATE	16, 32
	CHANGEOVER	
1^{00}	RATES ZFOG -10, 5 DUPLICATES IF NEEDED	
2^{00}		
3^{00}	TESTS	
4^{00}	RATES	
5^{00}		
6^{00}		

July 22, 1999
THURSDAY

HUNT OR SHERRI

7AM		
8:00	STARTUP	TEMP 1
9:00	RATES 1 ZFOG; LOUT, 2	
	FLUID 1, RATE 10, 25, 10, 25	
10:00		
11:00	TEST 1	CHANGE ICE CORE
	RATES 1	
12PM	TEMP CHANGE	
	RATE 2, FLUID 2, RATE 10, 25, 10, 25	TEMP 2
1:00		
	TEST 2	
2:00	RATE 2	
	TEMP CHANGE	CHANGE ICE CORE
3:00	RATE 3, FLUID 3, RATE 10, 25, 10, 25	TEMP 3
4:00	TEST 3	
	RATE 3	
5:00	TEMP CHANGE	
	RATE 4, FLUID 4, RATE 10, 25, 10, 25	TEMP 4
6:00		
	TEST 4	

7:00pm - 7:30pm RATE 4

ly 23, 1999
RIDAY

HUNT OR SHERRI

AM		
00	STARTUP	
00	RATES 1 ZFOG; LOUT, 2	
	FLUID 5, RATE 10, 25, 10, 25	TEMP 1
00		
00	TEST 1	
	RATES 1	
PM	TEMP CHANGE	CHANGE ICE CORE
	RATE 2 ZFOG; LOUT, 5	
00	FLUID 6, RATE 10, 25, 10, 25	TEMP 2
	TEST 2	
00	RATE 2	
	TEMP CHANGE	CHANGE ICE CORE
00	RATE 3	
	FLUID 7, RATE 10, 25, 10, 25	TEMP 3
00	TEST 3	
	RATE 3	
00	TEMP CHANGE	CHANGE ICE CORE
	RATE 4	
00	FLUID 8, RATE 10, 25, 10, 25	TEMP 4
	TEST 4	

7:00pm - 7:30pm RATE 4

July 24, 1999
SATURDAY

HUNT OR SHERRI

7^{AM}	SPLIT CHAMBER 1/2 AT -3 NCAR - TESTS @ -3 TO COMPLETE PREVIOIUS NRC TESTS
8^{00}	STARTUP X RATE 10, 25
9^{00}	RATES CSW; +1, 5
10^{00}	ULT+ RATE 10, 25 (LOW PRIORITY) TESTS
11^{00}	RATES
12^{PM}	CHANGEOVER PROP RATE 10, 25 (C1957) RATES CSW; +1, 75
1^{00}	
2^{00}	TESTS PROP 75/25 RATE 10, 25 (C1957)
3^{00}	RATES
4^{00}	
5^{00}	
6^{00}	

Attachment D-X
CEF DETAILED TEST PLAN

Test #	Precip Type	Temp. °C	Precip Rate g/dm²/hr	Fluid Brand	HOT Est. (min)	
1	Light Freezing Rain	-10	13	UCAR ADF	5	
2	Light Freezing Rain	-10	13	UCAR ADF	5	
3	Light Freezing Rain	-10	13	CLARIANT	5	
4	Light Freezing Rain	-10	13	CLARIANT	5	
5	Light Freezing Rain	-10	13	OCTAGON I	5	
6	Light Freezing Rain	-10	13	OCTAGON I	5	
7	Light Freezing Rain	-10	13	OCTAGON NEW	5	
8	Light Freezing Rain	-10	13	OCTAGON NEW	5	
9	Light Freezing Rain	-10	13	KILFROST	5	
10	Light Freezing Rain	-10	13	KILFROST	5	
11	Light Freezing Rain	-10	13	INLAND DURAGLY-P	5	
12	Light Freezing Rain	-10	13	INLAND DURAGLY-P	5	
13	Light Freezing Rain	-10	13	HO I	5	
14	Light Freezing Rain	-10	13	HO I	5	
15	Light Freezing Rain	-10	13	JAR I	5	
16	Light Freezing Rain	-10	13	JAR I	5	1.3
17	Light Freezing Rain	-10	25	UCAR ADF	2	
18	Light Freezing Rain	-10	25	UCAR ADF	2	
19	Light Freezing Rain	-10	25	CLARIANT	2	
20	Light Freezing Rain	-10	25	CLARIANT	2	
21	Light Freezing Rain	-10	25	OCTAGON I	2	
22	Light Freezing Rain	-10	25	OCTAGON I	2	
23	Light Freezing Rain	-10	25	OCTAGON NEW	2	
24	Light Freezing Rain	-10	25	OCTAGON NEW	2	
25	Light Freezing Rain	-10	25	KILFROST	2	
26	Light Freezing Rain	-10	25	KILFROST	2	
27	Light Freezing Rain	-10	25	INLAND DURAGLY-P	2	
28	Light Freezing Rain	-10	25	INLAND DURAGLY-P	2	
29	Light Freezing Rain	-10	25	HO I	2	
30	Light Freezing Rain	-10	25	HO I	2	
31	Light Freezing Rain	-10	25	JAR I	2	
32	Light Freezing Rain	-10	25	JAR I	2	0.5
				Total (min)	112	
				Total (hours)	2	

CEF DETAILED TEST PLAN - Freezing Drizzle

Test #	Precip Type	Temp. °C	Precip Rate g/dm²/hr	Fluid Brand	HOT Est. (min)	
1	Freezing Drizzle	-10	5	UCAR ADF	8	
2	Freezing Drizzle	-10	5	UCAR ADF	8	
3	Freezing Drizzle	-10	5	CLARIANT	8	
4	Freezing Drizzle	-10	5	CLARIANT	8	
5	Freezing Drizzle	-10	5	OCTAGON I	8	
6	Freezing Drizzle	-10	5	OCTAGON I	8	
7	Freezing Drizzle	-10	5	OCTAGON NEW	8	
8	Freezing Drizzle	-10	5	OCTAGON NEW	8	
9	Freezing Drizzle	-10	5	KILFROST	8	
10	Freezing Drizzle	-10	5	KILFROST	8	
11	Freezing Drizzle	-10	5	INLAND DURAGLY-P	8	
12	Freezing Drizzle	-10	5	INLAND DURAGLY-P	8	
13	Freezing Drizzle	-10	5	HO I	8	
14	Freezing Drizzle	-10	5	HO I	8	
15	Freezing Drizzle	-10	5	JAR I	8	
16	Freezing Drizzle	-10	5	JAR I	8	2.1
17	Freezing Drizzle	-10	13	UCAR ADF	5	
18	Freezing Drizzle	-10	13	UCAR ADF	5	
19	Freezing Drizzle	-10	13	CLARIANT	5	
20	Freezing Drizzle	-10	13	CLARIANT	5	
21	Freezing Drizzle	-10	13	OCTAGON I	5	
22	Freezing Drizzle	-10	13	OCTAGON I	5	
23	Freezing Drizzle	-10	13	OCTAGON NEW	5	
24	Freezing Drizzle	-10	13	OCTAGON NEW	5	
25	Freezing Drizzle	-10	13	KILFROST	5	
26	Freezing Drizzle	-10	13	KILFROST	5	
27	Freezing Drizzle	-10	13	INLAND DURAGLY-P	5	
28	Freezing Drizzle	-10	13	INLAND DURAGLY-P	5	
29	Freezing Drizzle	-10	13	HO I	5	
30	Freezing Drizzle	-10	13	HO I	5	
31	Freezing Drizzle	-10	13	JAR I	5	
32	Freezing Drizzle	-10	13	JAR I	5	1.3
				Total (min)	208	
				Total (hours)	3	

CEF DETAILED TEST PLAN - Cold Soak Box

Test #	Precip Type	Temp. °C	Precip Rate g/dm²/hr	Fluid Brand	HOT Est. (min)	
1	Cold Soak Box	1	5	UCAR ADF	5	
2	Cold Soak Box	1	5	UCAR ADF	5	
3	Cold Soak Box	1	5	CLARIANT	5	
4	Cold Soak Box	1	5	CLARIANT	5	
5	Cold Soak Box	1	5	OCTAGON I	5	
6	Cold Soak Box	1	5	OCTAGON I	5	
7	Cold Soak Box	1	5	OCTAGON NEW	5	
8	Cold Soak Box	1	5	OCTAGON NEW	5	
9	Cold Soak Box	1	5	KILFROST	5	
10	Cold Soak Box	1	5	KILFROST	5	
11	Cold Soak Box	1	5	INLAND DURAGLY-P	5	
12	Cold Soak Box	1	5	INLAND DURAGLY-P	5	
13	Cold Soak Box	1	5	HO I	5	
14	Cold Soak Box	1	5	HO I	5	
15	Cold Soak Box	1	5	JAR I	5	
16	Cold Soak Box	1	5	JAR I	5	1.3
17	Cold Soak Box	1	75	UCAR ADF	2	
18	Cold Soak Box	1	75	UCAR ADF	2	
19	Cold Soak Box	1	75	CLARIANT	2	
20	Cold Soak Box	1	75	CLARIANT	2	
21	Cold Soak Box	1	75	OCTAGON I	2	
22	Cold Soak Box	1	75	OCTAGON I	2	
23	Cold Soak Box	1	75	OCTAGON NEW	2	
24	Cold Soak Box	1	75	OCTAGON NEW	2	
25	Cold Soak Box	1	75	KILFROST	2	
26	Cold Soak Box	1	75	KILFROST	2	
27	Cold Soak Box	1	75	INLAND DURAGLY-P	2	
28	Cold Soak Box	1	75	INLAND DURAGLY-P	2	
29	Cold Soak Box	1	75	HO I	2	
30	Cold Soak Box	1	75	HO I	2	
31	Cold Soak Box	1	75	JAR I	2	
32	Cold Soak Box	1	75	JAR I	2	0.5
				Total (min)	112	
				Total (hours)	2	

CEF DETAILED TEST PLAN - Freezing Fog

Test #	Precip Type	Temp. °C	Precip Rate g/dm²/hr	Fluid Brand	HOT Est. (min)	
1	Freezing Fog	-10	2	UCAR ADF	15	
2	Freezing Fog	-10	2	UCAR ADF	15	
3	Freezing Fog	-10	2	CLARIANT	15	
4	Freezing Fog	-10	2	CLARIANT	15	
5	Freezing Fog	-10	2	OCTAGON I	15	
6	Freezing Fog	-10	2	OCTAGON I	15	
7	Freezing Fog	-10	2	OCTAGON NEW	15	
8	Freezing Fog	-10	2	OCTAGON NEW	15	
9	Freezing Fog	-10	2	KILFROST	15	
10	Freezing Fog	-10	2	KILFROST	15	
11	Freezing Fog	-10	2	INLAND DURAGLY-P	15	
12	Freezing Fog	-10	2	INLAND DURAGLY-P	15	
13	Freezing Fog	-10	2	HO I	15	
14	Freezing Fog	-10	2	HO I	15	
15	Freezing Fog	-10	2	JAR I	15	
16	Freezing Fog	-10	2	JAR I	15	4.0
17	Freezing Fog	-10	5	UCAR ADF	6	
18	Freezing Fog	-10	5	UCAR ADF	6	
19	Freezing Fog	-10	5	CLARIANT	6	
20	Freezing Fog	-10	5	CLARIANT	6	
21	Freezing Fog	-10	5	OCTAGON I	6	
22	Freezing Fog	-10	5	OCTAGON I	6	
23	Freezing Fog	-10	5	OCTAGON NEW	6	
24	Freezing Fog	-10	5	OCTAGON NEW	6	
25	Freezing Fog	-10	5	KILFROST	6	
26	Freezing Fog	-10	5	KILFROST	6	
27	Freezing Fog	-10	5	INLAND DURAGLY-P	6	
28	Freezing Fog	-10	5	INLAND DURAGLY-P	6	
29	Freezing Fog	-10	5	HO I	6	
30	Freezing Fog	-10	5	HO I	6	
31	Freezing Fog	-10	5	JAR I	6	
32	Freezing Fog	-10	5	JAR I	6	1.6

CEF DETAILED TEST PLAN - Freezing Fog

Test #	Precip Type	Temp. °C	Precip Rate g/dm²/hr	Fluid Brand	HOT Est. (min)	
33	Freezing Fog	Low T.	2	UCAR ADF	15	
34	Freezing Fog	Low T.	2	UCAR ADF	15	
35	Freezing Fog	Low T.	2	CLARIANT	15	
36	Freezing Fog	Low T.	2	CLARIANT	15	
37	Freezing Fog	Low T.	2	OCTAGON I	15	
38	Freezing Fog	Low T.	2	OCTAGON I	15	
39	Freezing Fog	Low T.	2	OCTAGON NEW	15	
40	Freezing Fog	Low T.	2	OCTAGON NEW	15	
41	Freezing Fog	Low T.	2	KILFROST	15	
42	Freezing Fog	Low T.	2	KILFROST	15	
43	Freezing Fog	Low T.	2	INLAND DURAGLY-P	15	
44	Freezing Fog	Low T.	2	INLAND DURAGLY-P	15	
45	Freezing Fog	Low T.	2	HO I	15	
46	Freezing Fog	Low T.	2	HO I	15	
47	Freezing Fog	Low T.	2	JAR I	15	
48	Freezing Fog	Low T.	2	JAR I	15	4.0
49	Freezing Fog	Low T.	5	UCAR ADF	6	
50	Freezing Fog	Low T.	5	UCAR ADF	6	
51	Freezing Fog	Low T.	5	CLARIANT	6	
52	Freezing Fog	Low T.	5	CLARIANT	6	
53	Freezing Fog	Low T.	5	OCTAGON I	6	
54	Freezing Fog	Low T.	5	OCTAGON I	6	
55	Freezing Fog	Low T.	5	OCTAGON NEW	6	
56	Freezing Fog	Low T.	5	OCTAGON NEW	6	
57	Freezing Fog	Low T.	5	KILFROST	6	
58	Freezing Fog	Low T.	5	KILFROST	6	
59	Freezing Fog	Low T.	5	INLAND DURAGLY-P	6	
60	Freezing Fog	Low T.	5	INLAND DURAGLY-P	6	
61	Freezing Fog	Low T.	5	HO I	6	
62	Freezing Fog	Low T.	5	HO I	6	
63	Freezing Fog	Low T.	5	JAR I	6	
64	Freezing Fog	Low T.	5	JAR I	6	1.6
				Total (min)	**672 min**	
				Total (hours)	**11.2 hrs**	

ATTACHMENT D-X

CEF DETAILED TEST PLAN - Snow

Test #	Precip Type	Temp. °C	Precip Rate $g/dm^2/hr$	Fluid Brand	HOT Est. (min)	
1	Snow (NCAR)	-10	10	UCAR ADF	15	
2	Snow (NCAR)	-10	10	UCAR ADF	15	
3	Snow (NCAR)	-10	10	CLARIANT	15	
4	Snow (NCAR)	-10	10	CLARIANT	15	
5	Snow (NCAR)	-10	10	OCTAGON I	15	
6	Snow (NCAR)	-10	10	OCTAGON I	15	
7	Snow (NCAR)	-10	10	OCTAGON NEW	15	
8	Snow (NCAR)	-10	10	OCTAGON NEW	15	
9	Snow (NCAR)	-10	10	KILFROST	15	
10	Snow (NCAR)	-10	10	KILFROST	15	
11	Snow (NCAR)	-10	10	INLAND DURAGLY-P	15	
12	Snow (NCAR)	-10	10	INLAND DURAGLY-P	15	
13	Snow (NCAR)	-10	10	HO I	15	
14	Snow (NCAR)	-10	10	HO I	15	
15	Snow (NCAR)	-10	10	JAR I	15	
16	Snow (NCAR)	-10	10	JAR I	15	4 hrs
17	Snow (NCAR)	-10	25	UCAR ADF	6	
18	Snow (NCAR)	-10	25	UCAR ADF	6	
19	Snow (NCAR)	-10	25	CLARIANT	6	
20	Snow (NCAR)	-10	25	CLARIANT	6	
21	Snow (NCAR)	-10	25	OCTAGON I	6	
22	Snow (NCAR)	-10	25	OCTAGON I	6	
23	Snow (NCAR)	-10	25	OCTAGON NEW	6	
24	Snow (NCAR)	-10	25	OCTAGON NEW	6	
25	Snow (NCAR)	-10	25	KILFROST	6	
26	Snow (NCAR)	-10	25	KILFROST	6	
27	Snow (NCAR)	-10	25	INLAND DURAGLY-P	6	
28	Snow (NCAR)	-10	25	INLAND DURAGLY-P	6	
29	Snow (NCAR)	-10	25	HO I	6	
30	Snow (NCAR)	-10	25	HO I	6	
31	Snow (NCAR)	-10	25	JAR I	6	
32	Snow (NCAR)	-10	25	JAR I	6	1.6 hrs

CEF DETAILED TEST PLAN - Snow (cont.)

Test #	Precip Type	Temp. °C	Precip Rate g/dm²/hr	Fluid Brand	HOT Est. (min)	
33	Snow (NCAR)	Low T.	10	UCAR ADF	15	
34	Snow (NCAR)	Low T.	10	UCAR ADF	15	
35	Snow (NCAR)	Low T.	10	CLARIANT	15	
36	Snow (NCAR)	Low T.	10	CLARIANT	15	
37	Snow (NCAR)	Low T.	10	OCTAGON I	15	
38	Snow (NCAR)	Low T.	10	OCTAGON I	15	
39	Snow (NCAR)	Low T.	10	OCTAGON NEW	15	
40	Snow (NCAR)	Low T.	10	OCTAGON NEW	15	
41	Snow (NCAR)	Low T.	10	KILFROST	15	
42	Snow (NCAR)	Low T.	10	KILFROST	15	
43	Snow (NCAR)	Low T.	10	INLAND DURAGLY-P	15	
44	Snow (NCAR)	Low T.	10	INLAND DURAGLY-P	15	
45	Snow (NCAR)	Low T.	10	HO I	15	
46	Snow (NCAR)	Low T.	10	HO I	15	
47	Snow (NCAR)	Low T.	10	JAR I	15	
48	Snow (NCAR)	Low T.	10	JAR I	15	4 hrs
49	Snow (NCAR)	Low T.	25	UCAR ADF	6	
50	Snow (NCAR)	Low T.	25	UCAR ADF	6	
51	Snow (NCAR)	Low T.	25	CLARIANT	6	
52	Snow (NCAR)	Low T.	25	CLARIANT	6	
53	Snow (NCAR)	Low T.	25	OCTAGON I	6	
54	Snow (NCAR)	Low T.	25	OCTAGON I	6	
55	Snow (NCAR)	Low T.	25	OCTAGON NEW	6	
56	Snow (NCAR)	Low T.	25	OCTAGON NEW	6	
57	Snow (NCAR)	Low T.	25	KILFROST	6	
58	Snow (NCAR)	Low T.	25	KILFROST	6	
59	Snow (NCAR)	Low T.	25	INLAND DURAGLY-P	6	
60	Snow (NCAR)	Low T.	25	INLAND DURAGLY-P	6	
61	Snow (NCAR)	Low T.	25	HO I	6	
62	Snow (NCAR)	Low T.	25	HO I	6	
63	Snow (NCAR)	Low T.	25	JAR I	6	
64	Snow (NCAR)	Low T.	25	JAR I	6	1.6 hrs
				Total (min)	672 min	
				Total (hours)	11.2 hrs	

ATTACHMENT D-XI

NRC COLD CHAMBER TESTS - JULY 1999

TEST EQUIPMENT CHECKLIST

TASK	*NRC Cold Chamber*	
	Resp.	**Status**
Make Hotel reservations	JK	
Rent Van/Car	JK	
Test Equipment		
Stand x 1	HUNT	
NCAR snow machine	HUNT	
Water for snowmaker	ER	
Hand-Held Tempearture Probes X 2	ER	
Hard water for dilution	ER	
Cups to pour 1 litre of Type I (X 24)	ER	Buy
Precipitation rate software (Observer)	ER	
Birds eye view camera	MH	
Covers for CSW	ER	
CSW equipment	ER/HUNT	
Sump Pumpa	ER	Buy
Labtop Computer x 2	MH	
Still Photo Camera	MH	
Digital Video Camera	MH	
Weigh Scales x 2	ER	
Video Camera X 2 (Surf & Snow) + Access.	MH	
Reg. Plates X 12	HUNT	
Data Forms for plates	MC	
Precipitation rate Data Forms	MC	
Reports + Tables (Temperature conversion, Dilution, ..)	MC	
Large Precipitation Pans x 36	HUNT	
Type I Fluids	MC	
Type IV Fluids	HUNT	
Clipboards x 3	HUNT	
Pencils + Space pens x 4	HUNT	
Paper Towels	HUNT	
Rubber squeegees	HUNT	
Plastic Refills for Fluids and funnels	HUNT	
Electrical Extension Cords	HUNT	
Lighting x 2	HUNT	
Stop watches x 4	HUNT	
Storage bins for small equipment	HUNT	
Protective clothing (All)	HUNT	
Brixometer X 3	HUNT	
Tie wraps	HUNT	
Funnels	HUNT	
Thickness Gauges	HUNT	
Microscope & Accessories	MC	
Big Digital Clock	ER	
Scrapers	HUNT	
Cooling Unit + fluid for it	ER/HUNT/MC	
Cold-Soaked Boxes 7.5 cm X 6 cm	HUNT	
Thermocouple Kit + Logger for CSW	HUNT	Put in freezer
Digital level	HUNT	
Test Procedures X 10	MC	
Fluid waste containers	MC	
Shopvac	HUNT	
Printers (Brother & Epson)	MH	
Detailed rate pans	ER	
Paint brushes for plate cleaning	ER	
32 Red containers	HUNT	PAINT
Headsets	MH	
Rate shelf	HUNT	
Empty bottles for samples	ER	
Computers and monitors	MH	
Measurement containers X 2	ER	BUY
Cradles	HUNT	
Excel software for detailed rates	MH	
Weigh Scale (1 gram)	HUNT	bring to office
Preweigh minerals	ER	
Big Plastic container	ER	Buy
Washers	HUNT	

ATTACHMENT D-XII

TRIALS TO ASSESS THE PERFORMANCE OF THE NCAR SNOW GENERATION SYSTEM

CM1514.001

EXPERIMENTAL PROGRAM

TRIALS TO ASSESS THE PERFORMANCE OF THE NCAR SNOW GENERATION SYSTEM

Winter 1998-99

APS AVIATION INC.

May 7, 2007
Version 1.1

EXPERIMENTAL PROGRAM
TRIALS TO ASSESS THE PERFORMANCE OF THE NCAR SNOW GENERATION SYSTEM

Winter 1998/99

This set of tests will produce the data required for evaluating the snow precipitation conditions produced by the NCAR snow generation system.

1. OBJECTIVES

The purpose of these tests is to evaluate the NCAR system for the future conduct of holdover time testing and documentation of fluid failure appearances in simulated snow conditions.

The tests required to create holdover time tables for snow conditions will be performed for a reference fluid and two known fluids.

The documentation of fluid failure appearance tests will be preformed for a reference fluid and thee known fluids.

Snow types will be observed during the tests.

2. TEST REQUIREMENTS

Trials will be conducted at PMG Technologies or at NRC in Ottawa.

All Type IV fluids must be tested at outside air temperature. If the cold chamber is not maintained at low temperatures over night, the fluids must be refrigerated to ensure temperature is according to requirements.

Type I fluids must be at room temperature until the test is performed. They must not be stored in the cold chamber.

Temperatures of -3°C, -14°C, -25°C and 7°C above fluid freezing point are required for the holdover time tests.

Temperatures of -3°C and -10°C are required for the documentation of fluid failure appearance tests.

Attachment I presents a test matrix for these tests.

3 EQUIPMENT

Attachment II presents a list of required equipment for the holdover time tests.

The list of equipment required for the documentation of fluid failure appearance tests is included in the *Experimental Program Procedure for the Documentation of the Appearance of Failed Fluids for Indoor Tests*. The C/FIMS sensor should be used if available, but the C/FIMS computer will not be required for these tests.

4 PERSONNEL

The personnel requirements for the holdover time tests are as follows:

- One person to pour the fluids and to call the failure on the plate.
- One person part-time to assist in preparing the snow generation system and to verify it's correct operation.

The personnel requirements for the documentation of fluid failure appearance tests are as indicated in the *Experimental Program Procedure for the Documentation of the Appearance of Failed Fluids for Outdoor Tests*, with the exception that the Meteo Tester is not required since the rates are collected by the NCAR system.

5 SUMMARY OF PROCEDURES

The procedures for the holdover time tests are as indicated in the *Experimental Program For Dorval Natural Precipitation Flat Plate Testing* with the exception that the plate rate pans are not required since the rates are collected by the NCAR system.

The procedures for the documentation of fluid failure appearance tests are as indicated in the *Experimental Program Procedure for the Documentation of the Appearance of Failed Fluids for Indoor Tests*, with the exception that the plate rate pans are not required since the rates are collected by the NCAR system. The RVSI sensor will not be used for the snow making tests.

The following is the list of steps that must be followed for each NCAR test

-Empty bucket on weight scale.
-Verify that scale is within range and not near overloading
-Check if ice core is solid and long sufficient for the following test.
    If not   back ice core away from drill
        change ice core
        move ice core forward to drill, stop when precipitation has started
        stop forward motion
-Input desired precipitation rate
-Start precipitation and logging. If logging was already in progress, stop and restart.
-Pour fluid and close door.
-Call failures
-Once failure times are recorded stop NCAR and include the following in the comment section
    -Test start time
    -Test end time
    -Fluid
    -Precipitation rate desired
    -Exact outside air temperature
    -Run number
-IF THE FILE IS NOT A VALID TEST LOG, WRITE "DISREGUARD" IN THE COMMENT SECTION AND SAVE THE FILE AS "JUNK_##"

6 DATA FORM

The holdover time tests will only require the end condition data form.

The documentation of fluid failure appearance tests require the completion of the data forms included in the *Experimental Program Procedure for the Documentation of the Appearance of Failed Fluids for Indoor Tests*. The Meteo/Plate pan data form is not required since the rates are not collected manually.

APPENDIX E

LOG OF FLAT PLATE TESTS – 1998-99

NATURAL SNOW TESTS AT DORVAL 1998-99

Test No.	Date	Fluid Dilution	Fluid Name	Fluid Type	Fail Time [min.]	Rate of Precip (g/dm^2/hr)	READAC Data	
							Temp [C]	Wind Sp [kph]
1	Dec-19-98	Std	UCAR XL54	1	35	0.9	-6.7	19
2	Dec-19-98	Std	UCAR XL54	1	36	0.9	-6.7	19
3	Dec-19-98	Std	CLARIANT SAFEWING 1938	1	26	0.9	-6.6	19
4	Dec-19-98	Std	CLARIANT SAFEWING 1938	1	31	1.2	-6.6	19
5	Dec-19-98	Std	UCAR XL54	1	15	4.5	-6.4	15
6	Dec-19-98	Std	UCAR XL54	1	15	4.5	-6.4	15
7	Dec-19-98	Std	CLARIANT SAFEWING 1938	1	11	4.9	-6.4	16
8	Dec-19-98	Std	CLARIANT SAFEWING 1938	1	11	4.9	-6.4	16
9	Dec-19-98	Std	UCAR XL54	1	14	5.4	-6.1	16
10	Dec-19-98	Std	UCAR XL54	1	12	5.3	-6.1	15
11	Dec-19-98	Std	CLARIANT SAFEWING 1938	1	11	5.3	-6.2	16
12	Dec-19-98	Std	CLARIANT SAFEWING 1938	1	11	5.3	-6.2	16
13	Dec-19-98	Std	UCAR XL54	1	12	5.7	-6.0	14
14	Dec-19-98	Std	UCAR XL54	1	12	5.7	-6.0	14
15	Dec-21-98	Neat	CLARIANT SAFEWING 1906	2	50	7.8	-6.1	17
16	Dec-21-98	Neat	CLARIANT SAFEWING 1906	2	50	7.8	-6.1	17
17	Dec-21-98	Neat	CLARIANT SAFEWING 1906	2	55	9.7	-6.1	19
18	Dec-21-98	Neat	CLARIANT SAFEWING 1906	2	55	9.7	-6.1	19
19	Dec-21-98	Neat	CLARIANT SAFEWING 1906	2	39	14.6	-6.8	22
20	Dec-21-98	Neat	CLARIANT SAFEWING 1906	2	46	14.0	-6.8	22
21	Jan-06-99	75%	SPCA AD-480	4b	80	5.9	-7.2	11
22	Jan-06-99	75%	SPCA AD-480	4b	81	5.9	-7.2	11
23	Jan-08-99	75%	SPCA AD-480	4b	64	6.5	-7.5	17
24	Jan-08-99	75%	SPCA AD-480	4b	63	6.5	-7.5	17
25	Jan-08-99	Neat	SPCA AD-480	4	84	6.7	-7.5	15
26	Jan-08-99	Neat	SPCA AD-480	4	85	6.7	-7.5	15
27	Jan-08-99	Neat	SPCA AD-480	4	88	10.9	-7.6	11
28	Jan-08-99	Neat	SPCA AD-480	4	85	10.5	-7.6	12
29	Jan-08-99	Neat	SPCA AD-480	4	85	10.5	-7.6	12
30	Jan-08-99	75%	SPCA AD-480	4b	59	9.8	-7.6	12
31	Jan-08-99	75%	SPCA AD-480	4b	59	9.8	-7.6	12
32	Jan-08-99	Std	INLAND DURAGLY-E	1	4	14.2	-7.5	11
33	Jan-08-99	Std	INLAND DURAGLY-E	1	4	14.2	-7.5	11
34	Jan-08-99	Std	OCTAGON	1	5	14.2	-7.5	11
35	Jan-08-99	Std	OCTAGON	1	5	14.2	-7.5	11
36	Jan-08-99	Std	UCAR XL54	1	6	14.2	-7.5	11
37	Jan-08-99	Std	UCAR XL54	1	6	14.2	-7.5	11
38	Jan-08-99	75%	SPCA AD-480	4b	63	6.0	-8.7	11
39	Jan-08-99	75%	SPCA AD-480	4b	63	6.0	-8.7	11
40	Jan-08-99	75%	SPCA AD-480	4b	64	6.2	-9.0	11
41	Jan-08-99	75%	SPCA AD-480	4b	64	6.2	-9.0	11
42	Jan-09-99	Std	UCAR XL54	1	6	15.7	-9.7	17
43	Jan-09-99	Std	UCAR XL54	1	7	15.7	-9.7	17
44	Jan-09-99	Std	OCTAGON	1	4	15.7	-9.7	17
45	Jan-09-99	Std	OCTAGON	1	4	15.7	-9.7	17
46	Jan-09-99	Std	INLAND DURAGLY-E	1	3	15.7	-9.7	17

NATURAL SNOW TESTS AT DORVAL 1998-99

Test No.	Date	Fluid Dilution	Fluid Name	Fluid Type	Fail Time [min.]	Rate of Precip (g/dm²/hr)	READAC Data	
							Temp [C]	Wind Sp [kph]
47	Jan-08,09-99	Std	UCAR XL54	1	5	12.3	-9.7	18
48	Jan-08,09-99	Std	UCAR XL54	1	4	12.3	-9.7	17
49	Jan-08,09-99	Std	INLAND DURAGLY-E	1	4	12.3	-9.7	17
50	Jan-08,09-99	Std	INLAND DURAGLY-E	1	5	12.3	-9.7	17
51	Jan-09-99	Std	OCTAGON	1	4	12.3	-9.7	16
52	Jan-09-99	Std	OCTAGON	1	4	12.3	-9.7	16
53	Jan-09-99	Std	UCAR XL54	1	3	23.4	-9.7	20
54	Jan-09-99	Std	OCTAGON	1	3	23.4	-9.8	20
55	Jan-09-99	Std	INLAND DURAGLY-E	1	3	23.4	-9.8	20
56	Jan-09-99	Std	INLAND DURAGLY-E	1	3	23.4	-9.8	20
57	Jan-09-99	Neat	SPCA AD-480	4	71	15.8	-9.7	20
58	Jan-09-99	Neat	SPCA AD-480	4	71	15.8	-9.7	20
59	Jan-09-99	75%	SPCA AD-480	4b	38	19.3	-9.7	20
60	Jan-09-99	75%	SPCA AD-480	4b	38	19.3	-9.7	20
61	Jan-09-99	Neat	SPCA AD-480	4	124	6.3	-9.5	18
62	Jan-09-99	Neat	SPCA AD-480	4	140	4.5	-9.4	18
63	Jan-09-99	Std	OCTAGON	1	7	8.7	-9.0	19
64	Jan-09-99	Std	UCAR XL54	1	7	8.7	-9.0	19
65	Jan-09-99	Std	INLAND DURAGLY-E	1	7	8.7	-9.0	19
66	Jan-09-99	75%	SPCA AD-480	4b	73	8.5	-8.8	16
67	Jan-09-99	75%	SPCA AD-480	4b	95	7.9	-8.8	16
68	Jan-09-99	75%	SPCA AD-480	4b	79	8.0	-8.1	12
69	Jan-09-99	Neat	SPCA AD-480	4	106	4.0	-8.1	12
70	Jan-09-99	Std	OCTAGON	1	11	6.2	-8.1	13
71	Jan-09-99	75%	SPCA AD-480	4b	80	8.9	-8.1	12
72	Jan-09-99	Std	UCAR XL54	1	10	6.2	-8.1	13
73	Jan-09-99	Std	INLAND DURAGLY-E	1	14	6.2	-8.1	12
74	Jan-12-99	Neat	SPCA AD-480	4	47	8.5	-20.1	23
75	Jan-12-99	Neat	SPCA AD-480	4	47	8.5	-20.1	23
76	Jan-12-99	Neat	SPCA AD-480	4	45	8.5	-20.1	23
77	Jan-12-99	Neat	SPCA AD-480	4	45	8.5	-20.1	23
78	Jan-12-99	Neat	SPCA AD-480	4	34	10.0	-20.1	24
79	Jan-12-99	Neat	SPCA AD-480	4	34	10.0	-20.1	24
80	Jan-12-99	Neat	SPCA AD-480	4	32	10.0	-20.1	24
81	Jan-12-99	Neat	SPCA AD-480	4	32	10.0	-20.1	24
82	Jan-14-99	Std	INLAND DURAGLY-E	1	7	6.9	-17.0	21
83	Jan-14-99	Std	INLAND DURAGLY-E	1	6	6.9	-17.0	21
84	Jan-14-99	Std	INLAND DURAGLY-E	1	6	6.9	-17.0	21
85	Jan-15-99	Std	Fluid X	X	62	14.0	-15.9	20
86	Jan-15-99	Std	Fluid X	X	59	14.0	-16.0	20
87	Jan-15-99	Neat	SPCA AD-480	4	36	9.6	-16.0	20
88	Jan-15-99	Neat	SPCA AD-480	4	33	9.6	-16.0	20
89	Jan-15-99	Std	Fluid X	X	49	17.6	-14.9	22
90	Jan-15-99	Std	Fluid X	X	51	17.9	-14.9	22
91	Jan-15-99	Neat	SPCA AD-480	4	47	17.5	-14.9	22
92	Jan-15-99	Neat	SPCA AD-480	4	47	17.5	-14.9	22
93	Jan-15-99	Neat	SPCA AD-480	4	32	26.6	-14.3	25
94	Jan-15-99	Neat	SPCA AD-480	4	32	26.6	-14.3	25

NATURAL SNOW TESTS AT DORVAL 1998-99

Test No.	Date	Fluid Dilution	Fluid Name	Fluid Type	Fail Time [min.]	Rate of Precip (g/dm²/hr)	READAC Data	
							Temp [C]	Wind Sp [kph]
95	Jan-15-99	75%	SPCA AD-480	4b	11	57.0	-13.5	29
96	Jan-15-99	75%	SPCA AD-480	4b	10	57.0	-13.5	29
97	Jan-15-99	Std	INLAND DURAGLY-E	1	3	31.0	-13.6	28
98	Jan-15-99	Std	INLAND DURAGLY-E	1	3	31.0	-13.6	28
99	Jan-15-99	Std	INLAND DURAGLY-E	1	4	31.0	-13.6	28
100	Jan-15-99	75%	SPCA AD-480	4b	12	62.0	-13.4	28
101	Jan-15-99	75%	SPCA AD-480	4b	12	62.0	-13.4	28
102	Jan-15-99	75%	SPCA AD-480	4b	37	25.3	-12.2	24
103	Jan-15-99	75%	SPCA AD-480	4b	36	25.3	-12.2	24
104	Jan-15-99	Neat	SPCA AD-480	4	43	24.5	-12.1	23
105	Jan-15-99	Neat	SPCA AD-480	4	43	24.5	-12.1	23
106	Jan-15-99	Std	Fluid X	X	40	23.1	-11.2	23
107	Jan-15-99	Std	Fluid X	X	42	23.1	-11.2	23
108	Jan-15-99	Std	Fluid X	X	34	23.9	-10.3	22
109	Jan-15-99	Std	Fluid X	X	37	23.9	-10.3	22
110	Jan-15-99	Std	INLAND DURAGLY-E	1	4	25.4	-10.5	20
111	Jan-15-99	Std	INLAND DURAGLY-E	1	5	25.4	-10.5	21
112	Jan-15-99	Std	Fluid X	X	38	28.0	-9.7	21
113	Jan-15-99	Std	Fluid X	X	40	28.0	-9.7	21
114	Jan-15-99	Std	INLAND DURAGLY-E	1	4	26.7	-9.8	20
115	Jan-15-99	Std	INLAND DURAGLY-E	1	5	26.7	-9.8	21
116	Jan-15-99	Std	Fluid X	X	56	17.5	-15.9	20
117	Jan-15-99	Std	UCAR XL54	1	7	9.4	-16.0	19
118	Jan-15-99	Std	Fluid X	X	33	26.6	-14.3	25
119	Jan-15-99	Std	UCAR XL54	1	3	30.2	-14.1	24
120	Feb-06-99	75%	KILFROST ABC-S	4b	102	3.9	-7.2	11
121	Feb-06-99	75%	KILFROST ABC-S	4b	105	4.1	-7.2	11
122	Feb-06-99	75%	KILFROST ABC-II PLUS	2b	70	4.5	-7.4	12
123	Feb-06-99	75%	KILFROST ABC-II PLUS	2b	71	4.5	-7.4	12
124	Feb-06-99	Neat	KILFROST ABC-II PLUS	2	101	3.9	-7.2	11
125	Feb-06-99	Neat	KILFROST ABC-II PLUS	2	100	3.9	-7.2	11
126	Feb-06-99	Std	Fluid X	X	109	8.1	-6.6	10
127	Feb-06-99	Std	Fluid X	X	110	8.1	-6.6	10
128	Feb-06-99	75%	KILFROST ABC-II PLUS	2b	63	6.2	-6.7	10
129	Feb-06-99	75%	KILFROST ABC-II PLUS	2b	61	6.1	-6.7	10
130	Feb-06-99	75%	CLARIANT SAFEWING MP IV 1957	4b	74	7.1	-6.7	10
131	Feb-06-99	75%	CLARIANT SAFEWING MP IV 1957	4b	75	7.2	-6.7	10
132	Feb-06-99	Std	INLAND DURAGLY-E	1	7	12.5	-6.5	9
133	Feb-06-99	Std	INLAND DURAGLY-E	1	7	12.7	-6.5	9
134	Feb-06-99	75%	KILFROST ABC-S	4b	52	8.9	-6.4	10
135	Feb-06-99	75%	KILFROST ABC-S	4b	55	8.8	-6.4	10
136	Feb-06-99	Std	INLAND DURAGLY-E	1	14	7.4	-6.6	12
137	Feb-06-99	Std	INLAND DURAGLY-E	1	13	7.4	-6.6	12
138	Feb-06-99	75%	CLARIANT SAFEWING MP IV 1957	4b	45	10.7	-6.5	10
139	Feb-06-99	75%	CLARIANT SAFEWING MP IV 1957	4b	47	10.6	-6.5	10
140	Feb-06-99	Neat	KILFROST ABC-II PLUS	2	61	10.6	-6.5	10
141	Feb-06-99	Neat	KILFROST ABC-II PLUS	2	61	10.6	-6.5	10
142	Feb-06-99	75%	KILFROST ABC-S	4b	60	10.6	-6.5	10

NATURAL SNOW TESTS AT DORVAL 1998-99

Test No.	Date	Fluid Dilution	Fluid Name	Fluid Type	Fail Time [min.]	Rate of Precip (g/dm²/hr)	READAC Data	
							Temp [C]	Wind Sp [kph]
143	Feb-06-99	75%	KILFROST ABC-S	4b	62	10.6	-6.5	10
144	Feb-06-99	Std	INLAND DURAGLY-E	1	8	10.6	-6.4	10
145	Feb-06-99	Std	INLAND DURAGLY-E	1	8	10.6	-6.4	10
146	Feb-06-99	Neat	CLARIANT SAFEWING MP IV 1957	4	71	6.0	-7.0	14
147	Feb-06-99	Neat	CLARIANT SAFEWING MP IV 1957	4	71	6.0	-7.0	14
148	Feb-06-99	75%	CLARIANT SAFEWING MP IV 1957	4b	65	6.0	-7.0	14
149	Feb-06-99	75%	CLARIANT SAFEWING MP IV 1957	4b	67	6.0	-7.0	14
150	Feb-06-99	Neat	KILFROST ABC-II PLUS	2	81	6.0	-7.0	14
151	Feb-06-99	Neat	KILFROST ABC-II PLUS	2	77	6.0	-7.0	14
152	Feb-06-99	75%	KILFROST ABC-II PLUS	2b	74	5.4	-7.3	15
153	Feb-06-99	75%	KILFROST ABC-II PLUS	2b	76	5.4	-7.4	15
154	Feb-06-99	Std	INLAND DURAGLY-E	1	18	3.9	-7.6	13
155	Feb-06-99	Std	INLAND DURAGLY-E	1	19	3.9	-7.6	13
156	Feb-12-99	Neat	UCAR ULTRA +	4	113	5.6	-0.4	22
157	Feb-12-99	Neat	UCAR ULTRA +	4	124	5.5	-0.4	21
158	Feb-12-99	50%	KILFROST ABC-II PLUS	2a	79	4.2	-0.3	23
159	Feb-12-99	50%	KILFROST ABC-II PLUS	2a	80	4.2	-0.3	23
160	Feb-12-99	50%	KILFROST ABC-S	4a	72	4.1	-0.3	24
161	Feb-12-99	50%	KILFROST ABC-S	4a	72	4.1	-0.3	24
162	Feb-12-99	50%	KILFROST ABC-S	4a	14	13.1	-0.6	19
163	Feb-12-99	50%	KILFROST ABC-S	4a	14	13.1	-0.6	19
164	Feb-12-99	50%	KILFROST ABC-II PLUS	2a	36	7.9	-0.6	17
165	Feb-12-99	50%	CLARIANT SAFEWING MP IV 1957	4a	34	7.9	-0.6	17
166	Feb-12-99	50%	CLARIANT SAFEWING MP IV 1957	4a	35	7.9	-0.6	17
167	Feb-28-99	75%	KILFROST ABC-II PLUS	2b	49	13.0	0.8	15
168	Feb-28-99	75%	KILFROST ABC-II PLUS	2b	49	13.0	0.8	15
169	Feb-28-99	75%	CLARIANT SAFEWING MP IV 1957	4b	46	13.0	0.8	15
170	Feb-28-99	75%	CLARIANT SAFEWING MP IV 1957	4b	47	13.0	0.8	15
171	Feb-28-99	75%	OCTAGON MAXFLIGHT	4b	72	13.8	0.8	15
172	Feb-28-99	75%	OCTAGON MAXFLIGHT	4b	73	13.8	0.8	15
173	Feb-28-99	Std	INLAND DURAGLY-P	1	13	14.2	0.8	15
174	Feb-28-99	Std	INLAND DURAGLY-P	1	12	14.2	0.9	15
175	Feb-28-99	Std	INLAND DURAGLY-E	1	12	14.2	0.9	15
176	Feb-28-99	Std	INLAND DURAGLY-E	1	12	14.2	0.9	15
177	Feb-28-99	50%	OCTAGON MAXFLIGHT	4a	19	20.5	0.7	13
178	Feb-28-99	50%	OCTAGON MAXFLIGHT	4a	21	20.5	0.7	13
179	Feb-28-99	50%	CLARIANT SAFEWING MP IV 1957	4a	18	20.5	0.7	13
180	Feb-28-99	50%	CLARIANT SAFEWING MP IV 1957	4a	18	20.5	0.7	13
181	Feb-28-99	50%	KILFROST ABC-II PLUS	2a	23	20.0	0.6	13
182	Feb-28-99	50%	KILFROST ABC-II PLUS	2a	25	20.0	0.6	13
183	Feb-28-99	50%	KILFROST ABC-S	4a	13	20.0	0.6	12
184	Feb-28-99	50%	KILFROST ABC-S	4a	13	20.0	0.6	12
185	Feb-28-99	50%	CLARIANT SAFEWING MP IV 1957	4a	19	20.0	0.6	13
186	Feb-28-99	50%	CLARIANT SAFEWING MP IV 1957	4a	20	20.0	0.6	13
187	Feb-28-99	Std	INLAND DURAGLY-P	1	12	13.1	0.6	13
188	Feb-28-99	Std	INLAND DURAGLY-P	1	13	12.9	0.6	13
189	Feb-28-99	Neat	KILFROST ABC-II PLUS	2	110	6.6	0.8	9
190	Feb-28-99	Neat	KILFROST ABC-II PLUS	2	110	6.6	0.8	9

NATURAL SNOW TESTS AT DORVAL 1998-99

Test No.	Date	Fluid Dilution	Fluid Name	Fluid Type	Fail Time [min.]	Rate of Precip (g/dm^2/hr)	READAC Data	
							Temp [C]	Wind Sp [kph]
191	Feb-28-99	Neat	CLARIANT SAFEWING MP IV 1957	4	100	6.7	0.8	9
192	Feb-28-99	Neat	CLARIANT SAFEWING MP IV 1957	4	107	6.6	0.8	9
193	Feb-28-99	Std	INLAND DURAGLY-P	1	15	8.7	0.9	8
194	Feb-28-99	Std	INLAND DURAGLY-P	1	15	8.7	0.9	8
195	Feb-28-99	Std	INLAND DURAGLY-E	1	14	8.7	0.9	8
196	Feb-28-99	Std	INLAND DURAGLY-E	1	14	8.7	0.9	8
197	Feb-28-99	75%	CLARIANT SAFEWING MP IV 1957	4b	95	6.1	0.8	8
198	Feb-28-99	75%	CLARIANT SAFEWING MP IV 1957	4b	94	6.1	0.8	8
199	Feb-28-99	50%	OCTAGON MAXFLIGHT	4a	65	5.4	0.9	8
200	Feb-28-99	50%	OCTAGON MAXFLIGHT	4a	65	5.4	0.9	8
201	Feb-28-99	50%	KILFROST ABC-II PLUS	2a	62	5.3	0.9	8
202	Feb-28-99	50%	KILFROST ABC-II PLUS	2a	63	5.4	0.9	8
203	Mar-02-99	75%	KILFROST ABC-II PLUS	2b	90	6.5	-1.2	24
204	Mar-02-99	75%	KILFROST ABC-II PLUS	2b	92	6.4	-1.2	24
205	Mar-02-99	75%	KILFROST ABC-S	4b	58	8.6	-1.1	24
206	Mar-02-99	75%	KILFROST ABC-S	4b	59	8.5	-1.1	24
207	Mar-02-99	75%	CLARIANT SAFEWING MP IV 1957	4b	85	6.5	-1.2	24
208	Mar-02-99	75%	CLARIANT SAFEWING MP IV 1957	4b	84	6.6	-1.2	24
209	Mar-02-99	Std	INLAND DURAGLY-P	1	40	3.1	-1.3	24
210	Mar-02-99	Std	INLAND DURAGLY-P	1	41	3.1	-1.3	24
211	Mar-02-99	50%	OCTAGON MAXFLIGHT	4a	28	11.8	-0.9	24
212	Mar-02-99	50%	OCTAGON MAXFLIGHT	4a	35	10.8	-0.9	24
213	Mar-02-99	50%	CLARIANT SAFEWING MP IV 1957	4a	23	11.3	-0.8	24
214	Mar-02-99	50%	CLARIANT SAFEWING MP IV 1957	4a	25	11.3	-0.9	24
215	Mar-02-99	50%	KILFROST ABC-II PLUS	2a	67	3.3	-1.3	24
216	Mar-02-99	50%	KILFROST ABC-II PLUS	2a	70	3.3	-1.4	24
217	Mar-02-99	50%	KILFROST ABC-S	4a	42	3.3	-1.3	24
218	Mar-02-99	50%	KILFROST ABC-S	4a	44	3.3	-1.3	24
219	Mar-02-99	50%	OCTAGON MAXFLIGHT	4a	68	3.3	-1.4	24
220	Mar-02-99	50%	OCTAGON MAXFLIGHT	4a	76	3.3	-1.4	25
221	Mar-02-99	50%	CLARIANT SAFEWING MP IV 1957	4a	130	1.0	-2.3	27
222	Mar-02-99	50%	CLARIANT SAFEWING MP IV 1957	4a	136	1.0	-2.3	27
223	Mar-02-99	50%	OCTAGON MAXFLIGHT	4a	266	0.8	-3.0	27
224	Mar-02-99	50%	OCTAGON MAXFLIGHT	4a	267	0.8	-3.0	27
225	Mar-02-99	Std	INLAND DURAGLY-P	1	100	0.6	-3.7	28
226	Mar-02-99	Std	INLAND DURAGLY-P	1	100	0.6	-3.7	28
227	Mar-02-99	Std	INLAND DURAGLY-E	1	100	0.6	-3.7	28
228	Mar-02-99	Std	INLAND DURAGLY-E	1	99	0.6	-3.7	28
229	Mar-03-99	Std	Fluid X	X	41	26.8	-1.8	17
230	Mar-03-99	Neat	KILFROST ABC-II PLUS	2	34	25.2	-1.8	17
231	Mar-03-99	Neat	UCAR ULTRA +	4	37	25.6	-1.8	17
232	Mar-03-99	Neat	CLARIANT SAFEWING MP IV 1957	4	33	25.2	-1.8	17
233	Mar-03-99	Neat	KILFROST ABC-S	4	51	32.3	-1.8	17
234	Mar-03-99	Neat	OCTAGON MAXFLIGHT	4	44	32.3	-1.8	18
235	Mar-03-99	50%	KILFROST ABC-II PLUS	2a	12	28.4	-1.7	17
236	Mar-03-99	50%	KILFROST ABC-II PLUS	2a	13	28.4	-1.7	17
237	Mar-03-99	50%	KILFROST ABC-S	4a	9	28.4	-1.7	17
238	Mar-03-99	50%	KILFROST ABC-S	4a	9	28.4	-1.7	17

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Test No.	Date	Fluid Dilution	Fluid Name	Fluid Type	Fail Time [min.]	Rate of Precip (g/dm²/hr)	READAC Data	
							Temp [C]	Wind Sp [kph]
239	Mar-03-99	50%	CLARIANT SAFEWING MP IV 1957	4a	13	28.4	-1.7	18
240	Mar-03-99	50%	CLARIANT SAFEWING MP IV 1957	4a	13	28.4	-1.7	18
241	Mar-03-99	75%	KILFROST ABC-II PLUS	2b	40	22.2	-1.8	16
242	Mar-03-99	75%	KILFROST ABC-II PLUS	2b	39	22.2	-1.8	16
243	Mar-03-99	75%	KILFROST ABC-S	4b	34	23.1	-1.8	16
244	Mar-03-99	75%	KILFROST ABC-S	4b	36	22.2	-1.8	16
245	Mar-03-99	75%	CLARIANT SAFEWING MP IV 1957	4b	35	22.2	-1.8	16
246	Mar-03-99	75%	CLARIANT SAFEWING MP IV 1957	4b	34	22.5	-1.8	16
247	Mar-03-99	Neat	CLARIANT SAFEWING MP IV 1957	4	46	17.2	-1.6	16
248	Mar-03-99	Neat	CLARIANT SAFEWING MP IV 1957	4	46	17.2	-1.6	16
249	Mar-03-99	Neat	KILFROST ABC-II PLUS	2	44	16.8	-1.6	16
250	Mar-03-99	Neat	KILFROST ABC-II PLUS	2	45	17.2	-1.6	16
251	Mar-03-99	Neat	KILFROST ABC-S	4	78	22.3	-1.4	16
252	Mar-03-99	Neat	KILFROST ABC-S	4	84	22.7	-1.4	16
253	Mar-03-99	50%	OCTAGON MAXFLIGHT	4a	19	32.9	-1.3	14
254	Mar-03-99	50%	OCTAGON MAXFLIGHT	4a	19	32.9	-1.3	14
255	Mar-03-99	50%	KILFROST ABC-II PLUS	2a	25	28.6	-1.3	15
256	Mar-03-99	50%	KILFROST ABC-II PLUS	2a	24	28.7	-1.3	15
257	Mar-03-99	Neat	OCTAGON MAXFLIGHT	4	61	16.5	-1.6	16
258	Mar-03-99	Neat	CLARIANT SAFEWING MP IV 1957	4	50	11.9	-1.6	16
259	Mar-03-99	Neat	UCAR ULTRA +	4	57	15.6	-1.6	16
260	Mar-03-99	Neat	KILFROST ABC-II PLUS	2	49	11.9	-1.6	16
261	Mar-03-99	Neat	KILFROST ABC-S	4	77	20.6	-1.5	15
262	Mar-03-99	Std	INLAND DURAGLY-P	1	7	38.8	-1.3	14
263	Mar-03-99	Std	INLAND DURAGLY-P	1	7	38.8	-1.3	14
264	Mar-03-99	Std	INLAND DURAGLY-E	1	7	38.8	-1.3	14
265	Mar-03-99	Std	INLAND DURAGLY-E	1	7	38.8	-1.3	14
266	Mar-03-99	Std	UCAR XL54	1	7	28.9	-1.3	15
267	Mar-03-99	50%	OCTAGON MAXFLIGHT	4a	18	12.1	-1.4	14
268	Mar-03-99	50%	OCTAGON MAXFLIGHT	4a	18	12.1	-1.4	14
269	Mar-03-99	50%	CLARIANT SAFEWING MP IV 1957	4a	15	11.6	-1.4	13
270	Mar-03-99	50%	CLARIANT SAFEWING MP IV 1957	4a	16	12.1	-1.4	13
271	Mar-03-99	75%	OCTAGON MAXFLIGHT	4b	36	26.7	-1.2	15
272	Mar-03-99	75%	OCTAGON MAXFLIGHT	4b	36	26.7	-1.2	15
273	Mar-03-99	75%	KILFROST ABC-S	4b	20	30.9	-1.3	14
274	Mar-03-99	75%	KILFROST ABC-S	4b	26	28.7	-1.3	15
275	Mar-03-99	Neat	OCTAGON MAXFLIGHT	4	57	14.9	-0.8	17
276	Mar-03-99	Neat	OCTAGON MAXFLIGHT	4	66	13.0	-0.7	17
277	Mar-03-99	Neat	UCAR ULTRA +	4	52	14.9	-0.9	17
278	Mar-03-99	Neat	UCAR ULTRA +	4	54	14.9	-0.9	17
279	Mar-04-99	50%	KILFROST ABC-S	4a	12	20.3	0.8	32
280	Mar-04-99	50%	KILFROST ABC-S	4a	13	20.3	0.8	32
281	Mar-04-99	50%	OCTAGON MAXFLIGHT	4a	21	16.0	0.5	32
282	Mar-04-99	50%	OCTAGON MAXFLIGHT	4a	22	15.6	0.5	32
283	Mar-04-99	50%	CLARIANT SAFEWING MP IV 1957	4a	34	6.6	-1.7	31
284	Mar-04-99	50%	CLARIANT SAFEWING MP IV 1957	4a	39	6.6	-1.7	31
285	Mar-04-99	50%	KILFROST ABC-II PLUS	2a	38	6.6	-1.7	31
286	Mar-04-99	50%	KILFROST ABC-II PLUS	2a	41	6.6	-1.7	31

NATURAL SNOW TESTS AT DORVAL 1998-99

Test No.	Date	Fluid Dilution	Fluid Name	Fluid Type	Fail Time [min.]	Rate of Precip (g/dm²/hr)	READAC Data	
							Temp [C]	Wind Sp [kph]
287	Mar-06-99	Neat	KILFROST ABC-S	4	112	4.8	-13.4	24
288	Mar-06-99	Neat	KILFROST ABC-S	4	112	4.8	-13.4	24
289	Mar-06-99	Neat	OCTAGON MAXFLIGHT	4	82	4.5	-13.5	24
290	Mar-06-99	Neat	OCTAGON MAXFLIGHT	4	83	4.5	-13.5	24
291	Mar-06-99	Neat	UCAR ULTRA +	4	106	4.8	-13.4	24
292	Mar-06-99	Neat	UCAR ULTRA +	4	108	4.8	-13.4	24
293	Mar-06-99	75%	OCTAGON MAXFLIGHT	4b	62	5.5	-13.6	24
294	Mar-06-99	75%	OCTAGON MAXFLIGHT	4b	61	5.6	-13.6	24
295	Mar-06-99	Neat	UCAR ULTRA +	4	117	5.7	-13.4	24
296	Mar-06-99	Neat	UCAR ULTRA +	4	118	5.7	-13.4	24
297	Mar-06-99	75%	OCTAGON MAXFLIGHT	4b	59	5.6	-13.6	23
298	Mar-06-99	75%	OCTAGON MAXFLIGHT	4b	60	5.5	-13.6	23
299	Mar-06-99	Neat	KILFROST ABC-II PLUS	2	45	6.1	-13.4	24
300	Mar-06-99	Neat	KILFROST ABC-II PLUS	2	47	6.1	-13.4	24
301	Mar-06-99	Neat	KILFROST ABC-S	4	120	4.7	-13.3	24
302	Mar-06-99	Neat	KILFROST ABC-S	4	121	4.7	-13.3	24
303	Mar-06-99	Neat	CLARIANT SAFEWING MP IV 1957	4	83	5.3	-13.3	25
304	Mar-06-99	Neat	CLARIANT SAFEWING MP IV 1957	4	87	5.2	-13.3	25
305	Mar-06-99	Neat	OCTAGON MAXFLIGHT	4	86	4.6	-13.2	26
306	Mar-06-99	Neat	OCTAGON MAXFLIGHT	4	88	4.6	-13.2	26
307	Mar-06-99	Neat	KILFROST ABC-S	4	124	4.4	-13.2	26
308	Mar-06-99	Neat	KILFROST ABC-S	4	124	4.4	-13.2	26
309	Mar-06-99	Neat	CLARIANT SAFEWING MP IV 1957	4	77	4.6	-13.2	26
310	Mar-06-99	Neat	CLARIANT SAFEWING MP IV 1957	4	77	4.6	-13.2	26
311	Mar-06-99	Neat	OCTAGON MAXFLIGHT	4	92	4.5	-13.2	27
312	Mar-06-99	Neat	OCTAGON MAXFLIGHT	4	91	4.5	-13.2	27
313	Mar-06-99	Neat	UCAR ULTRA +	4	125	4.7	-13.1	26
314	Mar-06-99	Neat	UCAR ULTRA +	4	124	4.6	-13.1	26
315	Mar-06-99	Neat	CLARIANT SAFEWING MP IV 1957	4	80	4.6	-13.2	27
316	Mar-06-99	Neat	CLARIANT SAFEWING MP IV 1957	4	81	4.6	-13.2	27
317	Mar-06-99	75%	OCTAGON MAXFLIGHT	4b	75	5.5	-13.2	28
318	Mar-06-99	75%	OCTAGON MAXFLIGHT	4b	76	5.5	-13.2	28
319	Mar-06-99	75%	KILFROST ABC-S	4b	80	5.2	-13.2	28
320	Mar-06-99	75%	KILFROST ABC-S	4b	80	5.2	-13.2	28
321	Mar-06-99	75%	KILFROST ABC-II PLUS	2b	52	6.3	-13.3	28
322	Mar-06-99	75%	KILFROST ABC-II PLUS	2b	51	6.3	-13.3	28
323	Mar-06-99	Std	Fluid X	X	142	4.9	-12.8	26
324	Mar-06-99	Std	Fluid X	X	144	4.9	-12.8	26
325	Mar-06-99	Neat	KILFROST ABC-S	4	121	4.8	-12.9	26
326	Mar-06-99	Neat	KILFROST ABC-S	4	122	4.8	-12.9	26
327	Mar-06-99	Neat	OCTAGON MAXFLIGHT	4	97	4.7	-12.9	26
328	Mar-06-99	Neat	OCTAGON MAXFLIGHT	4	98	4.7	-12.9	26
329	Mar-06-99	Std	Fluid X	X	132	8.0	-12.6	26
330	Mar-06-99	Std	Fluid X	X	132	8.0	-12.6	26
331	Mar-06-99	Neat	UCAR ULTRA +	4	80	8.9	-12.6	25
332	Mar-06-99	Neat	UCAR ULTRA +	4	79	8.9	-12.6	25
333	Mar-06-99	75%	OCTAGON MAXFLIGHT	4b	45	5.7	-12.6	24
334	Mar-06-99	75%	OCTAGON MAXFLIGHT	4b	46	5.7	-12.6	24

NATURAL SNOW TESTS AT DORVAL 1998-99

Test No.	Date	Fluid Dilution	Fluid Name	Fluid Type	Fail Time [min.]	Rate of Precip (g/dm²/hr)	READAC Data	
							Temp [C]	Wind Sp [kph]
335	Mar-06-99	75%	CLARIANT SAFEWING MP IV 1957	4b	36	8.3	-12.6	25
336	Mar-06-99	75%	CLARIANT SAFEWING MP IV 1957	4b	36	8.3	-12.6	25
337	Mar-06-99	75%	KILFROST ABC-II PLUS	2b	29	7.1	-12.6	24
338	Mar-06-99	75%	KILFROST ABC-II PLUS	2b	29	7.1	-12.6	24
339	Mar-06-99	75%	OCTAGON MAXFLIGHT	4b	36	8.3	-12.6	25
340	Mar-06-99	75%	OCTAGON MAXFLIGHT	4b	37	8.3	-12.6	25
341	Mar-06-99	Std	Fluid X	X	112	8.0	-12.6	27
342	Mar-06-99	Std	Fluid X	X	114	7.7	-12.6	27
343	Mar-06-99	Neat	CLARIANT SAFEWING MP IV 1957	4	41	8.7	-12.6	25
344	Mar-06-99	Neat	CLARIANT SAFEWING MP IV 1957	4	43	8.7	-12.6	25
345	Mar-06-99	Neat	KILFROST ABC-II PLUS	2	28	8.1	-12.6	25
346	Mar-06-99	Neat	KILFROST ABC-II PLUS	2	27	8.1	-12.6	25
347	Mar-06-99	Std	UCAR XL54	1	12	6.7	-12.6	30
348	Mar-06-99	Std	UCAR XL54	1	11	6.7	-12.6	30
349	Mar-06-99	Std	INLAND DURAGLY-E	1	11	6.7	-12.6	30
350	Mar-06-99	Std	INLAND DURAGLY-E	1	10	6.7	-12.7	30
351	Mar-06-99	Std	INLAND DURAGLY-P	1	10	6.7	-12.7	29
352	Mar-06-99	Std	INLAND DURAGLY-P	1	9	6.7	-12.7	29
353	Mar-06-99	Neat	KILFROST ABC-S	4	117	4.8	-12.5	29
354	Mar-06-99	Neat	KILFROST ABC-S	4	120	4.8	-12.5	29
355	Mar-06-99	Neat	KILFROST ABC-II PLUS	2	48	5.4	-12.6	30
356	Mar-06-99	Neat	KILFROST ABC-II PLUS	2	48	5.4	-12.6	30
357	Mar-06-99	Neat	CLARIANT SAFEWING MP IV 1957	4	70	5.0	-12.6	30
358	Mar-06-99	Neat	CLARIANT SAFEWING MP IV 1957	4	72	5.0	-12.6	29
359	Mar-06-99	Neat	OCTAGON MAXFLIGHT	4	89	6.2	-12.4	29
360	Mar-06-99	Neat	OCTAGON MAXFLIGHT	4	100	4.6	-12.4	30
361	Mar-06-99	Neat	UCAR ULTRA +	4	91	5.4	-12.4	30
362	Mar-06-99	Neat	UCAR ULTRA +	4	94	5.4	-12.4	30
363	Mar-06-99	75%	KILFROST ABC-S	4b	84	4.9	-12.4	29
364	Mar-06-99	75%	KILFROST ABC-S	4b	85	4.9	-12.4	29
365	Mar-06-99	Neat	CLARIANT SAFEWING MP IV 1957	4	61	7.2	-12.3	32
366	Mar-06-99	Neat	CLARIANT SAFEWING MP IV 1957	4	72	8.1	-12.3	32
367	Mar-06-99	Neat	UCAR ULTRA +	4	79	8.2	-12.3	32
368	Mar-06-99	Neat	UCAR ULTRA +	4	79	8.2	-12.3	32
369	Mar-06-99	Neat	OCTAGON MAXFLIGHT	4	94	8.4	-12.3	32
370	Mar-06-99	Neat	OCTAGON MAXFLIGHT	4	94	8.4	-12.3	32
371	Mar-06-99	75%	KILFROST ABC-S	4b	69	7.9	-12.2	32
372	Mar-06-99	75%	KILFROST ABC-S	4b	71	7.5	-12.2	32
373	Mar-06-99	75%	KILFROST ABC-II PLUS	2b	32	8.1	-12.3	33
374	Mar-06-99	75%	KILFROST ABC-II PLUS	2b	34	8.1	-12.3	33
375	Mar-06-99	75%	OCTAGON MAXFLIGHT	4b	58	7.9	-12.2	32
376	Mar-06-99	75%	OCTAGON MAXFLIGHT	4b	62	7.9	-12.2	32
377	Mar-06-99	75%	CLARIANT SAFEWING MP IV 1957	4b	58	6.7	-12.0	35
378	Mar-06-99	75%	CLARIANT SAFEWING MP IV 1957	4b	55	6.6	-12.0	35
379	Mar-11-99	Neat	KILFROST ABC-S	4	190	3.9	-5.4	16
380	Mar-11-99	Neat	KILFROST ABC-S	4	189	3.8	-5.4	16
381	Mar-11-99	Neat	CLARIANT SAFEWING MP IV 1957	4	113	2.3	-5.3	13
382	Mar-11-99	Neat	CLARIANT SAFEWING MP IV 1957	4	115	2.3	-5.3	13

NATURAL SNOW TESTS AT DORVAL 1998-99

Test No.	Date	Fluid Dilution	Fluid Name	Fluid Type	Fail Time [min.]	Rate of Precip (g/dm²/hr)	READAC Data	
							Temp [C]	Wind Sp [kph]
383	Mar-11-99	Neat	OCTAGON MAXFLIGHT	4	113	2.3	-5.3	13
384	Mar-11-99	Neat	OCTAGON MAXFLIGHT	4	116	2.3	-5.3	13
385	Mar-11-99	75%	KILFROST ABC-II PLUS	2b	57	7.0	-5.6	20
386	Mar-11-99	75%	KILFROST ABC-II PLUS	2b	56	6.9	-5.5	20
387	Mar-11-99	75%	CLARIANT SAFEWING MP IV 1957	4b	55	6.9	-5.5	20
388	Mar-11-99	75%	CLARIANT SAFEWING MP IV 1957	4b	56	7.1	-5.5	20
389	Mar-11-99	75%	CLARIANT SAFEWING MP IV 1957	4b	98	3.6	-5.2	16
390	Mar-11-99	75%	CLARIANT SAFEWING MP IV 1957	4b	92	3.3	-5.1	16
391	Mar-11-99	75%	KILFROST ABC-S	4b	97	3.7	-5.2	16
392	Mar-11-99	75%	KILFROST ABC-S	4b	98	3.7	-5.2	16
393	Mar-11-99	75%	KILFROST ABC-II PLUS	2b	81	3.0	-5.1	15
394	Mar-11-99	75%	KILFROST ABC-II PLUS	2b	82	3.1	-5.1	15
395	Mar-11-99	75%	OCTAGON MAXFLIGHT	4b	50	12.6	-5.5	18
396	Mar-11-99	75%	OCTAGON MAXFLIGHT	4b	53	12.6	-5.5	18
397	Mar-11-99	75%	KILFROST ABC-S	4b	45	12.5	-5.5	18
398	Mar-11-99	75%	KILFROST ABC-S	4b	51	12.6	-5.5	18
399	Mar-11-99	Neat	KILFROST ABC-II PLUS	2	46	12.6	-5.5	18
400	Mar-11-99	Neat	KILFROST ABC-II PLUS	2	48	12.6	-5.5	18
401	Mar-11-99	Neat	CLARIANT SAFEWING MP IV 1957	4	48	11.5	-5.4	17
402	Mar-11-99	Neat	UCAR ULTRA +	4	59	11.6	-5.4	18
403	Mar-11-99	Neat	KILFROST ABC-S	4	97	10.7	-5.5	18
404	Mar-11-99	Neat	KILFROST ABC-S	4	93	10.7	-5.4	18
405	Mar-11-99	75%	OCTAGON MAXFLIGHT	4b	95	7.0	-5.7	18
406	Mar-11-99	75%	OCTAGON MAXFLIGHT	4b	92	7.1	-5.6	18
407	Mar-11-99	Neat	KILFROST ABC-II PLUS	2	87	6.7	-5.7	18
408	Mar-11-99	Neat	KILFROST ABC-II PLUS	2	91	6.7	-5.7	18
409	Mar-11-99	Neat	UCAR ULTRA +	4	65	9.2	-5.5	19
410	Mar-11-99	Neat	UCAR ULTRA +	4	66	9.2	-5.5	19
411	Mar-11-99	Neat	KILFROST ABC-S	4	126	7.0	-5.6	18
412	Mar-11-99	Neat	KILFROST ABC-S	4	135	6.8	-5.6	18
413	Mar-11-99	Neat	OCTAGON MAXFLIGHT	4	84	8.7	-5.5	18
414	Mar-11-99	Neat	OCTAGON MAXFLIGHT	4	105	7.6	-5.6	18
415	Mar-11-99	Std	Fluid X	X	229	3.8	-6.2	14
416	Mar-11-99	Std	Fluid X	X	235	3.8	-6.2	14
417	Mar-11-99	Neat	KILFROST ABC-S	4	169	3.3	-6.1	15
418	Mar-11-99	Neat	KILFROST ABC-S	4	174	3.5	-6.1	15
419	Mar-11-99	Neat	UCAR ULTRA +	4	151	3.3	-6.1	15
420	Mar-11-99	Neat	UCAR ULTRA +	4	153	3.3	-6.1	15
421	Mar-11-99	Neat	CLARIANT SAFEWING MP IV 1957	4	128	2.9	-6.2	14
422	Mar-11-99	Neat	CLARIANT SAFEWING MP IV 1957	4	130	1.6	-6.2	14
423	Mar-11-99	75%	CLARIANT SAFEWING MP IV 1957	4b	121	1.6	-6.2	14
424	Mar-11-99	75%	CLARIANT SAFEWING MP IV 1957	4b	122	2.8	-6.2	14
425	Mar-11-99	75%	KILFROST ABC-II PLUS	2b	125	2.9	-6.2	14
426	Mar-11-99	75%	KILFROST ABC-II PLUS	2b	124	2.9	-6.2	14
427	Mar-11-99	Neat	KILFROST ABC-S	4	162	4.0	-6.4	13
428	Mar-11-99	Neat	KILFROST ABC-S	4	167	4.0	-6.4	13
429	Mar-11-99	Neat	KILFROST ABC-II PLUS	2	89	4.0	-6.3	14
430	Mar-11-99	Neat	KILFROST ABC-II PLUS	2	92	4.0	-6.3	14

NATURAL SNOW TESTS AT DORVAL 1998-99

Test No.	Date	Fluid Dilution	Fluid Name	Fluid Type	Fail Time [min.]	Rate of Precip (g/dm^2/hr)	READAC Data	
							Temp [C]	Wind Sp [kph]
431	Mar-11-99	Neat	OCTAGON MAXFLIGHT	4	161	4.0	-6.4	13
432	Mar-11-99	Neat	OCTAGON MAXFLIGHT	4	162	4.0	-6.4	13
433	Mar-11-99	75%	OCTAGON MAXFLIGHT	4b	107	4.6	-6.6	13
434	Mar-11-99	75%	OCTAGON MAXFLIGHT	4b	107	4.6	-6.6	13
435	Mar-11-99	75%	KILFROST ABC-S	4b	88	4.2	-6.6	13
436	Mar-11-99	75%	KILFROST ABC-S	4b	89	4.2	-6.6	13
437	Mar-11-99	Neat	UCAR ULTRA +	4	93	4.4	-6.8	13
438	Mar-11-99	Neat	UCAR ULTRA +	4	100	4.4	-6.8	13
439	Mar-11-99	Neat	CLARIANT SAFEWING MP IV 1957	4	79	4.4	-6.8	13
440	Mar-11-99	Neat	CLARIANT SAFEWING MP IV 1957	4	77	4.4	-6.8	13
441	Mar-12-99	Std	UCAR XL54	1	12	5.6	-7.1	13
442	Mar-12-99	Std	UCAR XL54	1	12	5.6	-7.1	13
443	Mar-12-99	Std	INLAND DURAGLY-P	1	11	5.6	-7.1	13
444	Mar-12-99	Std	INLAND DURAGLY-P	1	12	5.6	-7.1	13
445	Mar-12-99	Std	INLAND DURAGLY-E	1	11	5.6	-7.1	13
446	Mar-12-99	Std	INLAND DURAGLY-E	1	11	5.6	-7.1	13
447	Mar-12-99	75%	CLARIANT SAFEWING MP IV 1957	4b	84	6.0	-7.6	15
448	Mar-12-99	75%	CLARIANT SAFEWING MP IV 1957	4b	85	6.0	-7.6	15
449	Mar-12-99	75%	KILFROST ABC-S	4b	88	5.7	-7.6	15
450	Mar-12-99	75%	KILFROST ABC-S	4b	82	6.0	-7.6	16
451	Mar-12-99	75%	KILFROST ABC-II PLUS	2b	79	6.0	-7.6	16
452	Mar-12-99	75%	KILFROST ABC-II PLUS	2b	89	5.7	-7.6	15
453	Mar-12-99	Neat	KILFROST ABC-II PLUS	2	104	5.7	-7.6	15
454	Mar-12-99	Neat	KILFROST ABC-II PLUS	2	104	5.7	-7.6	15
455	Mar-12-99	Neat	UCAR ULTRA +	4	116	5.2	-7.6	15
456	Mar-12-99	Neat	UCAR ULTRA +	4	121	5.0	-7.6	15
457	Feb-17-99	50%	OCTAGON MAXFLIGHT	4a	24	8.3	-1.3	17
458	Feb-17-99	50%	OCTAGON MAXFLIGHT	4a	25	8.2	-1.3	17
459	Feb-17-99	50%	KILFROST ABC-S	4a	16	9.2	-1.1	16
460	Feb-17-99	50%	KILFROST ABC-S	4a	18	8.9	-1.2	16
461	Feb-17-99	50%	KILFROST ABC-II PLUS	2a	128	2.2	-1.4	17
462	Feb-17-99	50%	KILFROST ABC-II PLUS	2a	128	2.2	-1.4	17
463	Feb-17-99	Std	INLAND DURAGLY-E	1	101	1.0	-1.5	17
464	Feb-17-99	Std	INLAND DURAGLY-E	1	101	1.0	-1.5	17
465	Feb-17-99	Std	INLAND DURAGLY-P	1	100	1.0	-1.5	17
466	Feb-17-99	Std	INLAND DURAGLY-P	1	100	1.0	-1.5	17
467	Mar-21-99	75%	CLARIANT SAFEWING MP IV 1957	4b	32	26.3	0.8	11
468	Mar-21-99	75%	CLARIANT SAFEWING MP IV 1957	4b	31	26.3	0.8	11
469	Mar-21-99	75%	KILFROST ABC-II PLUS	2b	34	26.3	0.8	11
470	Mar-21-99	75%	KILFROST ABC-II PLUS	2b	35	26.3	0.8	11
471	Mar-21-99	75%	KILFROST ABC-S	4b	30	26.3	0.8	11
472	Mar-21-99	75%	KILFROST ABC-S	4b	29	26.3	0.8	11
473	Mar-21-99	Neat	CLARIANT SAFEWING MP IV 1957	4	30	27.7	0.8	11
474	Mar-21-99	Neat	CLARIANT SAFEWING MP IV 1957	4	34	27.2	0.8	11
475	Mar-21-99	Neat	KILFROST ABC-S	4	68	28.7	0.8	12
476	Mar-21-99	Neat	KILFROST ABC-S	4	71	28.3	0.8	12
477	Mar-21-99	Neat	KILFROST ABC-II PLUS	2	30	27.4	0.8	11
478	Mar-21-99	Neat	KILFROST ABC-II PLUS	2	31	27.3	0.8	11

NATURAL SNOW TESTS AT DORVAL 1998-99

Test No.	Date	Fluid Dilution	Fluid Name	Fluid Type	Fail Time [min.]	Rate of Precip (g/dm²/hr)	READAC Data	
							Temp [C]	Wind Sp [kph]
479	Mar-21-99	75%	OCTAGON MAXFLIGHT	4b	40	29.5	0.8	13
480	Mar-21-99	75%	OCTAGON MAXFLIGHT	4b	42	29.9	0.8	13
481	Mar-21-99	Neat	UCAR ULTRA +	4	31	31.1	0.8	11
482	Mar-21-99	Neat	UCAR ULTRA +	4	33	31.5	0.8	11
483	Mar-21-99	Neat	OCTAGON MAXFLIGHT	4	50	28.0	0.7	12
484	Mar-21-99	Neat	OCTAGON MAXFLIGHT	4	52	27.8	0.7	12
485	Mar-21-99	75%	OCTAGON MAXFLIGHT	4b	45	28.5	0.7	12
486	Mar-21-99	75%	OCTAGON MAXFLIGHT	4b	47	28.3	0.7	12
487	Mar-21-99	Neat	KILFROST ABC-S	4	64	31.2	0.7	13
488	Mar-21-99	Neat	KILFROST ABC-S	4	63	31.2	0.7	13
489	Mar-21-99	Neat	OCTAGON MAXFLIGHT	4	59	31.2	0.7	13
490	Mar-21-99	Neat	OCTAGON MAXFLIGHT	4	58	31.2	0.7	13
491	Mar-22-99	75%	CLARIANT SAFEWING MP IV 1957	4b	24	45.2	0.7	14
492	Mar-22-99	75%	CLARIANT SAFEWING MP IV 1957	4b	24	45.2	0.7	14
493	Mar-22-99	75%	KILFROST ABC-II PLUS	2b	27	45.1	0.7	14
494	Mar-22-99	75%	KILFROST ABC-II PLUS	2b	27	45.1	0.7	14
495	Mar-22-99	50%	CLARIANT SAFEWING MP IV 1957	4a	12	33.7	0.6	16
496	Mar-22-99	50%	CLARIANT SAFEWING MP IV 1957	4a	13	33.7	0.6	15
497	Mar-22-99	50%	KILFROST ABC-S	4a	9	33.7	0.6	15
498	Mar-22-99	50%	KILFROST ABC-S	4a	9	33.7	0.6	15
499	Mar-22-99	50%	KILFROST ABC-II PLUS	2a	18	29.7	0.6	15
500	Mar-22-99	50%	KILFROST ABC-II PLUS	2a	18	29.7	0.6	15
501	Mar-22-99	Neat	CLARIANT SAFEWING MP IV 1957	4	36	29.1	0.6	15
502	Mar-22-99	Neat	CLARIANT SAFEWING MP IV 1957	4	37	28.9	0.6	15
503	Mar-22-99	Neat	OCTAGON MAXFLIGHT	4	116	12.0	0.8	18
504	Mar-22-99	Neat	OCTAGON MAXFLIGHT	4	119	12.4	0.8	18
505	Mar-22-99	75%	OCTAGON MAXFLIGHT	4b	98	9.7	0.8	19
506	Mar-22-99	75%	OCTAGON MAXFLIGHT	4b	100	9.7	0.8	19
507	Mar-22-99	75%	KILFROST ABC-S	4b	93	9.2	0.8	19
508	Mar-22-99	75%	KILFROST ABC-S	4b	93	9.2	0.8	19
509	Mar-22-99	75%	KILFROST ABC-II PLUS	2b	94	9.7	0.8	19
510	Mar-22-99	75%	KILFROST ABC-II PLUS	2b	96	9.7	0.8	19
511	Mar-22-99	Neat	KILFROST ABC-S	4	141	9.7	0.8	22
512	Mar-22-99	Neat	KILFROST ABC-S	4	140	9.7	0.8	22
513	Mar-22-99	Neat	UCAR ULTRA +	4	135	9.7	0.8	22
514	Mar-22-99	Neat	UCAR ULTRA +	4	136	9.7	0.8	22
515	Mar-22-99	75%	CLARIANT SAFEWING MP IV 1957	4b	90	9.5	0.8	21
516	Mar-22-99	75%	CLARIANT SAFEWING MP IV 1957	4b	96	9.6	0.8	21
517	Mar-22-99	75%	OCTAGON MAXFLIGHT	4b	125	9.8	0.8	21
518	Mar-22-99	75%	OCTAGON MAXFLIGHT	4b	125	9.8	0.8	21
519	Mar-22-99	Neat	KILFROST ABC-II PLUS	2	128	9.9	0.8	21
520	Mar-22-99	Neat	KILFROST ABC-II PLUS	2	128	9.9	0.8	21

NATURAL SNOW TESTS @ DORVAL 1998-99 (TYPE IV OVER TYPE I)

Test No.	Date	Fluid Dilution	Fluid Name	Fluid Type	Fail Time [min.]	Rate of Precip (g/dm²/hr)	READAC Data	
							Temp [C]	Wind Sp [kph]
1	Jan-09-99	Std/Std	UCAR UCAR XL54 / DURAGLY-E	1/0	4	23.4	-9.7	21
2	Jan-09-99	Std/Std	OCTAGON / DURAGLY-E	1/0	4	23.4	-9.7	19
3	Jan-09-99	Neat/std	UCAR UCAR ULTRA+ / DURAGLY-E	4/0	56	7.4	-9.7	16
4	Jan-09-99	Neat/std	OCTAGON MAX-FLIGHT/DURAGLY-E	4/0	51	7.4	-9.7	16
5	Jan-09-99	Neat/std	UCAR UCAR ULTRA+ / DURAGLY-E	4/0	70	11.0	-9.7	17
6	Jan-09-99	Neat/std	UCAR UCAR ULTRA+ / DURAGLY-E	4/0	61	6.5	-9.7	17
7	Jan-09-99	Neat/std	OCTAGON MAX-FLIGHT/DURAGLY-E	4/0	53	6.5	-9.7	16
8	Jan-09-99	Neat/std	UCAR UCAR ULTRA+ / DURAGLY-E	4/0	69	7.7	-9.7	17
9	Jan-09-99	Neat/std	UCAR UCAR ULTRA+ / DURAGLY-E	4/0	49	11.1	-9.6	19
10	Jan-09-99	Neat/std	OCTAGON MAX-FLIGHT/DURAGLY-E	4/0	45	11.1	-9.6	19
11	Jan-09-99	Neat/std	UCAR UCAR ULTRA+ / DURAGLY-E	4/0	44	11.1	-9.6	19
12	Jan-09-99	Neat/std	UCAR UCAR ULTRA+ / DURAGLY-E	4/0	59	6.6	-9.6	18
13	Jan-09-99	Neat/std	OCTAGON MAX-FLIGHT/DURAGLY-E	4/0	81	7.2	-9.5	18
14	Jan-09-99	Neat/std	UCAR UCAR ULTRA+ / DURAGLY-E	4/0	91	7.1	-9.5	18
15	Jan-09-99	Neat/std	UCAR ULTRA+/DURAGLY-E	4/0	65	8.7	-8.9	17
16	Jan-09-99	Neat/std	UCAR ULTRA+/DURAGLY-E	4/0	80	8.6	-8.9	17
17	Jan-09-99	Neat/std	OCTAGON MAX-FLIGHT/OCTAFLO	4/1	50	7.4	-9.7	16
18	Jan-09-99	Neat/std	OCTAGON MAX-FLIGHT/OCTAFLO	4/1	52	6.5	-9.7	16
19	Jan-09-99	Neat/std	OCTAGON MAX-FLIGHT/OCTAFLO	4/1	59	11.5	-9.5	18
20	Jan-09-99	Neat/std	OCTAGON MAX-FLIGHT/OCTAFLO	4/1	80	7.2	-9.5	18
21	Jan-09-99	Neat/std	UCAR ULTRA+/UCAR XL54	4/1	87	8.3	-8.9	17
22	Jan-09-99	Neat/std	OCTAGON MAX-FLIGHT/OCTAFLO	4/1	83	8.6	-8.9	17
23	Mar-06-99	Neat/std	UCAR ULTRA+/UCAR XL54	4/1	67	5.5	-11.9	34
24	Mar-06-99	Neat/std	OCTAGON MAX-FLIGHT/OCTAFLO	4/1	70	5.5	-11.9	34
25	Mar-06-99	Neat/0Eth	UCAR ULTRA+/DURAGLY-E	4/0	69	5.5	-11.9	34
26	Mar-06-99	Neat/0Pro	OCTAGON MAX-FLIGHT/DURAGLY-P	4/0	38	5.4	-11.8	33
27	Mar-06-99	Neat/0Pro	UCAR ULTRA+/DURAGLY-P	4/0	81	5.6	-11.9	34
28	Mar-06-99	Neat/0Eth	OCTAGON MAX-FLIGHT/DURAGLY-E	4/0	56	5.6	-11.9	33
29	Mar-06-99	Neat/std	CTAGON MAX-FLIGHT / CLARIANT 19	4/1	93	4.8	-12.0	34
30	Mar-06-99	Neat/std	UCAR ULTRA+ / UCAR XL54	4/1	111	4.7	-12.0	34
31	Mar-06-99	Neat/0PR	OCTAGON MAX-FLIGHT / DURAGLY-P	4/0	47	4.7	-11.9	33
32	Mar-06-99	Neat/0Eth	UCAR ULTRA+ / DURAGLY-E	4/0	92	4.8	-12.0	34
33	Mar-06-99	Neat/0Eth	OCTAGON MAX-FLIGHT / DURAGLY-E	4/0	55	4.7	-11.9	33
34	Mar-06-99	Neat/0PR	UCAR ULTRA+ / DURAGLY-P	4/0	85	4.8	-12.0	34
35	Mar-11-99	Neat/std	CLARIANT MP IV 1957/CLARIANT 1938	4/1	77	4.7	-6.9	13
36	Mar-11-99	Neat/std	UCAR ULTRA+ / UCAR XL54	4/1	94	4.5	-7.0	13
37	Mar-11-99	Neat/0Eth	CLARIANT MP IV 1957/DURAGLY-E	4/0	78	4.7	-6.9	13
38	Mar-11-99	Neat/0Eth	UCAR ULTRA+ / DURAGLY-E	4/0	101	4.3	-7.0	13
39	Mar-11-99	Neat/0Pro	CLARIANT MP IV 1957/DURAGLY-P	4/0	89	4.3	-7.0	13
40	Mar-11-99	Neat/0Pro	UCAR ULTRA+ / DURAGLY-P	4/0	126	4.0	-7.1	13
41	Mar-12-99	Neat/std	UCAR ULTRA+ / UCAR XL54	4/1	135	4.2	-7.4	14
42	Mar-12-99	Neat/std	CTAGON MAX-FLIGHT / CLARIANT 19	4/1	168	4.4	-7.5	15
43	Mar-12-99	Neat/0Eth	UCAR ULTRA+ / DURAGLY-E	4/0	135	4.2	-7.4	14
44	Mar-12-99	Neat/0Eth	OCTAGON MAX-FLIGHT / DURAGLY-E	4/0	130	4.0	-7.4	14
45	Mar-12-99	Neat/0Pro	UCAR ULTRA+ / DURAGLY-P	4/0	140	4.2	-7.4	14
46	Mar-12-99	Neat/0Pro	OCTAGON MAX-FLIGHT/DURAGLY-P	4/0	119	4.0	-7.4	14

NATURAL SNOW TESTS AT DORVAL 1998-99 (DIFFERENT PRECIPITATI

Test No.	Date	Fluid Dilution	Fluid Name	Fluid Type	Fail Time [min.]	Rate of Precip [g/dm^2/hr]	READAC Data	
							Temp [C]	Wind Sp [kph]
1	Dec-21-98	Std	UCAR XL54	1	27	2.6	-5.2	16
2	Dec-21-98	Std	UCAR XL54	1	27	2.6	-5.2	16
3	Dec-21-98	Std	UCAR XL54	1	26	2.6	-5.2	16
4	Dec-21-98	Std	UCAR XL54	1	28	2.6	-5.2	16
5	Feb-12-99	50%	CLARIANT SAFEWING MP IV 1957	4a	71	4.2	-0.3	23
6	Feb-12-99	50%	CLARIANT SAFEWING MP IV 1957	4a	71	4.2	-0.3	23
7	Feb-12-99	50%	KILFROST ABC-II PLUS	4a	73	4.2	-0.3	22
8	Feb-12-99	50%	KILFROST ABC-II PLUS	4a	74	4.2	-0.3	22

SIMULATED FREEZING DRIZZLE AND LIGHT FRZ RAIN AT CEF FOR 1998-99

Test No.	Date	Fluid Dilution	Fluid Name	Fluid Type	Fail Time [min.]	Rate of precep. [g/dm*^{2}/hr]	Ambient Temp (°C)	Precip Type
1	Mar-29-98	Neat	OCTAGON MAXFLIGHT	4	104.0	5.1	-3.4	frz_drizzle
2	Mar-29-99	Neat	CLARIANT SAFEWING MP IV 1957	4	73.0	4.8	-3.4	frz_drizzle
3	Mar-29-99	Neat	KILFROST ABC-S	4	192.0	4.6	-3.4	frz_drizzle
4	Mar-29-99	Neat	KILFROST ABC-II PLUS	2	68.0	5.4	-3.4	frz_drizzle
5	Mar-29-99	Neat	UCAR ULTRA +	4	96.0	4.9	-3.4	frz_drizzle
6	Mar-29-99	75%	CLARIANT SAFEWING MP IV 1957	4b	62.0	5.2	-3.4	frz_drizzle
7	Mar-29-99	50%	KILFROST ABC-S	4a	23.0	5.0	-3.4	frz_drizzle
8	Mar-29-99	75%	KILFROST ABC-II PLUS	2b	64.0	4.9	-3.4	frz_drizzle
9	Mar-29-99	75%	KILFROST ABC-S	4b	67.0	4.8	-3.4	frz_drizzle
10	Mar-29-99	50%	CLARIANT SAFEWING MP IV 1957	4a	24.0	5.5	-3.4	frz_drizzle
11	Mar-29-99	50%	KILFROST ABC-II PLUS	2a	27.0	4.9	-3.4	frz_drizzle
12	Mar-29-99	50%	OCTAGON MAXFLIGHT	4a	24.0	5.3	-3.4	frz_drizzle
13	Mar-29-99	Neat	OCTAGON MAXFLIGHT	4	116.0	4.9	-3.4	frz_drizzle
14	Mar-29-99	50%	KILFROST ABC-S	4a	23.0	4.4	-3.4	frz_drizzle
15	Mar-29-99	50%	OCTAGON MAXFLIGHT	4a	26.0	4.5	-3.5	frz_drizzle
16	Mar-29-99	50%	CLARIANT SAFEWING MP IV 1957	4a	23.0	4.1	-3.5	frz_drizzle
17	Mar-29-99	Neat	FLUID X	4	159.0	5.1	-3.4	frz_drizzle
18	Mar-29-99	50%	KILFROST ABC-II PLUS	2a	29.0	4.8	-3.4	frz_drizzle
19	Mar-30-99	75%	CLARIANT SAFEWING MP IV 1957	4b	72.0	4.7	-3.3	frz_drizzle
20	Mar-30-99	75%	KILFROST ABC-II PLUS	2b	59.0	5.2	-3.3	frz_drizzle
21	Mar-30-99	Neat	OCTAGON MAXFLIGHT	4	136.0	5.0	-3.3	frz_drizzle
22	Mar-30-99	Neat	KILFROST ABC-II PLUS	2	60.0	5.8	-3.3	frz_drizzle
23	Mar-30-99	Neat	KILFROST ABC-S	4	146.0	5.0	-3.3	frz_drizzle
24	Mar-30-99	Neat	FLUID X	4	149.0	5.3	-3.3	frz_drizzle
25	Mar-30-99	Neat	KILFROST ABC-S	4	157.0	6.1	-3.3	frz_drizzle
26	Mar-30-99	75%	OCTAGON MAXFLIGHT	4b	80.0	6.0	-3.3	frz_drizzle
27	Mar-30-99	Neat	CLARIANT SAFEWING MP IV 1957	4	65.0	5.6	-3.3	frz_drizzle
28	Mar-30-99	75%	KILFROST ABC-S	4b	70.0	5.7	-3.4	frz_drizzle
29	Mar-30-99	Std	INLAND DURAGLY-E	1	9.3	5.2	-3.4	frz_drizzle
30	Mar-30-99	Std	INLAND DURAGLY-P	1	12.3	5.4	-3.3	frz_drizzle
31	Mar-30-99	Std	UCAR XL54	1	11.8	5.3	-3.3	frz_drizzle
32	Mar-30-99	Std	CLARIANT 1938	1	11.2	5.3	-3.3	frz_drizzle
33	Mar-30-99	Neat	UCAR ULTRA +	4	122.0	4.0	-3.3	frz_drizzle
34	Mar-30-99	Neat	CLARIANT SAFEWING MP IV 1957	4	66.0	5.5	-3.4	frz_drizzle
35	Mar-30-99	Std	UCAR XL54	1	11.3	5.5	-3.3	frz_drizzle
36	Mar-30-99	Std	CLARIANT 1938	1	11.8	5.2	-3.3	frz_drizzle
37	Mar-30-99	Std	INLAND DURAGLY-E	1	9.4	5.3	-3.3	frz_drizzle
38	Mar-30-99	Std	INLAND DURAGLY-P	1	11.5	5.8	-3.3	frz_drizzle
39	Mar-31-99	75%	OCTAGON MAXFLIGHT	4b	73.0	4.9	-3.0	frz_drizzle
40	Mar-31-99	Neat	UCAR ULTRA +	4	88.0	5.0	-3.0	frz_drizzle
41	Mar-31-99	Neat	KILFROST ABC-S	4	130.0	4.9	-3.0	frz_drizzle
42	Mar-31-99	Neat	CLARIANT SAFEWING MP IV 1957	4	60.0	5.2	-3.0	frz_drizzle
43	Mar-31-99	75%	OCTAGON MAXFLIGHT	4b	86.0	5.0	-3.0	frz_drizzle
44	Mar-31-99	Std	UCAR XL54	1	12.2	5.4	-3.0	frz_drizzle
45	Mar-31-99	Std	CLARIANT 1938	1	11.3	5.3	-3.0	frz_drizzle
46	Mar-31-99	Std	INLAND DURAGLY-E	1	10.4	5.1	-3.0	frz_drizzle
47	Mar-31-99	Neat	OCTAGON MAXFLIGHT	4	112.0	5.5	-3.0	frz_drizzle
48	Mar-31-99	50%	OCTAGON MAXFLIGHT	4a	13.0	12.9	-2.6	frz_drizzle
49	Mar-31-99	50%	CLARIANT SAFEWING MP IV 1957	4a	15.0	12.5	-2.5	frz_drizzle
50	Mar-31-99	50%	KILFROST ABC-S	4a	14.0	12.5	-2.5	frz_drizzle
51	Mar-31-99	50%	KILFROST ABC-II PLUS	2a	7.0	12.8	-2.6	frz_drizzle

SIMULATED FREEZING DRIZZLE AND LIGHT FRZ RAIN AT CEF FOR 1998-99

Test No.	Date	Fluid Dilution	Fluid Name	Fluid Type	Fail Time [min.]	Rate of precep. [g/dm*²/hr]	Ambient Temp (°C)	Precip Type
52	Mar-31-99	50%	KILFROST ABC-II PLUS	2a	6.0	12.8	-2.6	frz_drizzle
53	Mar-31-99	50%	KILFROST ABC-S	4a	12.0	12.8	-2.5	frz_drizzle
54	Mar-31-99	50%	CLARIANT SAFEWING MP IV 1957	4a	15.0	13.1	-2.5	frz_drizzle
55	Mar-31-99	50%	OCTAGON MAXFLIGHT	4a	12.0	13.1	-2.5	frz_drizzle
56	Mar-31-99	Std	CLARIANT 1938	1	12.2	5.0	-2.9	frz_drizzle
57	Mar-31-99	Std	UCAR XL54	1	12.0	4.7	-2.9	frz_drizzle
58	Apr-01-99	Neat	KILFROST ABC-S	4	110.0	11.8	-2.8	frz_drizzle
59	Apr-01-99	Neat	FLUID X	4	123.0	11.8	-2.8	frz_drizzle
60	Apr-01-99	Neat	OCTAGON MAXFLIGHT	4	67.0	11.7	-2.8	frz_drizzle
61	Apr-01-99	Neat	CLARIANT SAFEWING MP IV 1957	4	36.0	13.0	-2.9	frz_drizzle
62	Apr-01-99	Neat	KILFROST ABC-II PLUS	2	32.0	12.9	-2.9	frz_drizzle
63	Apr-01-99	Neat	UCAR ULTRA +	4	40.0	12.6	-2.9	frz_drizzle
64	Apr-01-99	75%	CLARIANT SAFEWING MP IV 1957	4b	35.0	12.7	-2.9	frz_drizzle
65	Apr-01-99	75%	OCTAGON MAXFLIGHT	4b	47.0	13.1	-2.9	frz_drizzle
66	Apr-01-99	Neat	UCAR ULTRA +	4	51.0	11.7	-2.8	frz_drizzle
67	Apr-01-99	Neat	KILFROST ABC-II PLUS	2	40.0	11.4	-2.8	frz_drizzle
68	Apr-01-99	Neat	CLARIANT SAFEWING MP IV 1957	4	42.0	11.6	-2.8	frz_drizzle
69	Apr-01-99	75%	KILFROST ABC-S	4b	42.0	13.0	-2.9	frz_drizzle
70	Apr-01-99	Neat	FLUID X	4	107.0	12.8	-2.8	frz_drizzle
71	Apr-01-99	75%	KILFROST ABC-II PLUS	2b	26.0	12.8	-2.9	frz_drizzle
72	Apr-01-99	Neat	KILFROST ABC-S	4	110.0	13.1	-2.8	frz_drizzle
73	Apr-01-99	Neat	OCTAGON MAXFLIGHT	4	55.0	12.9	-2.8	frz_drizzle
74	Apr-01-99	75%	KILFROST ABC-S	4b	49.0	11.7	-2.8	frz_drizzle
75	Apr-01-99	Neat	UCAR ULTRA +	4	55.0	11.5	-2.7	frz_drizzle
76	Apr-01-99	Neat	KILFROST ABC-II PLUS	2	42.0	11.4	-2.7	frz_drizzle
77	Apr-01-99	75%	OCTAGON MAXFLIGHT	4b	49.0	11.5	-2.7	frz_drizzle
78	Apr-01-99	Neat	OCTAGON MAXFLIGHT	4	56.0	12.9	-2.8	frz_drizzle
79	Apr-01-99	75%	KILFROST ABC-II PLUS	2b	31.0	12.7	-2.8	frz_drizzle
80	Apr-01-99	75%	CLARIANT SAFEWING MP IV 1957	4b	38.0	12.7	-2.8	frz_drizzle
81	Apr-01-99	Std	CLARIANT 1938	1	8.2	11.5	-2.6	frz_drizzle
82	Apr-01-99	Std	UCAR XL54	1	9.9	12.4	-2.5	frz_drizzle
83	Apr-01-99	Std	INLAND DURAGLY-P	1	9.6	12.7	-2.6	frz_drizzle
84	Apr-01-99	Std	INLAND DURAGLY-E	1	9.0	12.9	-2.5	frz_drizzle
85	Apr-01-99	Std	UCAR XL54	1	7.9	11.5	-2.5	frz_drizzle
86	Apr-01-99	Std	CLARIANT 1938	1	10.0	12.7	-2.6	frz_drizzle
87	Apr-01-99	Std	INLAND DURAGLY-E	1	9.0	12.9	-2.5	frz_drizzle
88	Apr-01-99	Std	INLAND DURAGLY-P	1	8.8	12.6	-2.6	frz_drizzle
89	Apr-06-99	Neat	KILFROST ABC-S	4	87.0	24.7	-2.9	frz_RAIN
90	Apr-06-99	Neat	OCTAGON MAXFLIGHT	4	29.0	24.8	-2.8	frz_RAIN
91	Apr-06-99	Neat	FLUID X	4	72.0	24.9	-2.9	frz_RAIN
92	Apr-06-99	Neat	UCAR ULTRA +	4	25.0	25.3	-2.8	frz_RAIN
93	Apr-06-99	75%	OCTAGON MAXFLIGHT	4b	19.0	25.0	-2.8	frz_RAIN
94	Apr-06-99	Neat	CLARIANT SAFEWING MP IV 1957	4	28.0	25.2	-2.8	frz_RAIN
95	Apr-06-99	Neat	KILFROST ABC-II PLUS	2	28.0	25.3	-2.9	frz_RAIN
96	Apr-06-99	Neat	KILFROST ABC-S	4	79.0	24.7	-2.8	frz_RAIN
97	Apr-06-99	75%	KILFROST ABC-II PLUS	2b	22.0	24.6	-2.9	frz_RAIN
98	Apr-06-99	Neat	OCTAGON MAXFLIGHT	4	27.0	25.1	-2.9	frz_RAIN
99	Apr-06-99	Neat	FLUID X	4	73.0	24.7	-2.8	frz_RAIN
100	Apr-06-99	75%	OCTAGON MAXFLIGHT	4b	19.0	25.0	-2.8	frz_RAIN
101	Apr-06-99	75%	CLARIANT SAFEWING MP IV 1957	4b	26.0	25.1	-2.9	frz_RAIN
102	Apr-06-99	50%	OCTAGON MAXFLIGHT	4a	8.0	25.2	-2.7	frz_RAIN

SIMULATED FREEZING DRIZZLE AND LIGHT FRZ RAIN AT CEF FOR 1998-99

Test No.	Date	Fluid Dilution	Fluid Name	Fluid Type	Fail Time [min.]	Rate of precep. [g/dm*^{2}/hr]	Ambient Temp (°C)	Precip Type
103	Apr-06-99	75%	CLARIANT SAFEWING MP IV 1957	4b	27.0	24.7	-2.6	frz_RAIN
104	Apr-06-99	75%	KILFROST ABC-S	4b	32.0	24.4	-2.7	frz_RAIN
105	Apr-06-99	Neat	CLARIANT SAFEWING MP IV 1957	4	29.0	24.6	-2.7	frz_RAIN
106	Apr-06-99	50%	OCTAGON MAXFLIGHT	4a	8.0	24.5	-2.7	frz_RAIN
107	Apr-06-99	Neat	KILFROST ABC-II PLUS	2	28.0	25.1	-2.8	frz_RAIN
108	Apr-06-99	50%	KILFROST ABC-S	4a	9.0	24.6	-2.6	frz_RAIN
109	Apr-06-99	75%	KILFROST ABC-S	4b	34.0	24.5	-3.1	frz_RAIN
110	Apr-06-99	50%	KILFROST ABC-S	4a	9.0	24.5	-2.6	frz_RAIN
111	Apr-06-99	50%	KILFROST ABC-II PLUS	2a	6.0	24.2	-3.1	frz_RAIN
112	Apr-06-99	Neat	UCAR ULTRA +	4	28.0	24.5	-3.1	frz_RAIN
113	Apr-06-99	50%	KILFROST ABC-II PLUS	2a	5.5	24.3	-3.1	frz_RAIN
114	Apr-06-99	75%	KILFROST ABC-II PLUS	2b	21.0	24.7	-3.1	frz_RAIN
115	Apr-06-99	50%	CLARIANT SAFEWING MP IV 1957	4a	9.0	24.8	-3.1	frz_RAIN
116	Apr-06-99	50%	CLARIANT SAFEWING MP IV 1957	4a	9.0	24.4	-3.1	frz_RAIN
117	Apr-06-99	Std	INLAND DURAGLY-P	1	7.0	24.9	-3.1	frz_RAIN
118	Apr-06-99	Neat	UCAR ULTRA +	4	28.0	24.5	-3.1	frz_RAIN
119	Apr-06-99	Neat	CLARIANT SAFEWING MP IV 1957	4	30.0	24.4	-3.1	frz_RAIN
120	Apr-06-99	Std	CLARIANT 1938	1	7.8	25.0	-3.0	frz_RAIN
121	Apr-06-99	Neat	CLARIANT SAFEWING MP IV 1957	4	30.0	24.9	-3.1	frz_RAIN
122	Apr-06-99	Neat	KILFROST ABC-S	4	83.0	23.6	-3.1	frz_RAIN
123	Apr-06-99	Neat	UCAR ULTRA +	4	27.0	24.0	-3.1	frz_RAIN
124	Apr-06-99	Std	INLAND DURAGLY-E	1	7.8	24.6	-2.9	frz_RAIN
125	Apr-06-99	Std	INLAND DURAGLY-P	1	8.1	24.3	-2.9	frz_RAIN
126	Apr-06-99	Std	UCAR XL54	1	7.0	24.2	-2.9	frz_RAIN
127	Apr-06-99	Std	INLAND DURAGLY-E	1	7.8	23.7	-2.9	frz_RAIN
128	Apr-06-99	Std	UCAR XL54	1	7.5	23.9	-2.9	frz_RAIN
129	Apr-06-99	Std	CLARIANT 1938	1	7.0	24.2	-2.9	frz_RAIN
130	Apr-07-99	Neat	FLUID X	4	108.0	13.2	-3.1	frz_RAIN
131	Apr-07-99	Neat	KILFROST ABC-S	4	126.0	13.0	-3.1	frz_RAIN
132	Apr-07-99	Neat	CLARIANT SAFEWING MP IV 1957	4	42.0	13.1	-3.2	frz_RAIN
133	Apr-07-99	Neat	UCAR ULTRA +	4	40.0	12.9	-3.2	frz_RAIN
134	Apr-07-99	Neat	KILFROST ABC-II PLUS	2	40.0	13.0	-3.2	frz_RAIN
135	Apr-07-99	Neat	OCTAGON MAXFLIGHT	4	47.0	12.8	-3.2	frz_RAIN
136	Apr-07-99	Neat	UCAR ULTRA +	4	41.0	12.3	-3.1	frz_RAIN
137	Apr-07-99	75%	KILFROST ABC-S	4b	48.0	12.5	-3.2	frz_RAIN
138	Apr-07-99	Neat	KILFROST ABC-S	4	124.0	12.5	-3.1	frz_RAIN
139	Apr-07-99	75%	OCTAGON MAXFLIGHT	4b	44.0	12.5	-3.2	frz_RAIN
140	Apr-07-99	Neat	FLUID X	4	110.0	13.3	-3.1	frz_RAIN
141	Apr-07-99	75%	KILFROST ABC-S	4b	49.0	12.8	-3.1	frz_RAIN
142	Apr-07-99	Neat	OCTAGON MAXFLIGHT	4	49.0	13.0	-3.1	frz_RAIN
143	Apr-07-99	Neat	CLARIANT SAFEWING MP IV 1957	4	43.0	12.8	-3.1	frz_RAIN
144	Apr-07-99	75%	CLARIANT SAFEWING MP IV 1957	4b	39.0	12.4	-3.0	frz_RAIN
145	Apr-07-99	75%	OCTAGON MAXFLIGHT	4b	40.0	12.6	-3.1	frz_RAIN
146	Apr-07-99	Neat	KILFROST ABC-II PLUS	2	41.0	12.7	-3.1	frz_RAIN
147	Apr-07-99	50%	OCTAGON MAXFLIGHT	4a	12.0	13.2	-3.0	frz_RAIN
148	Apr-07-99	50%	CLARIANT SAFEWING MP IV 1957	4a	15.0	13.0	-3.1	frz_RAIN
149	Apr-07-99	75%	KILFROST ABC-II PLUS	2b	40.0	12.6	-3.2	frz_RAIN
150	Apr-07-99	50%	CLARIANT SAFEWING MP IV 1957	4a	15.0	12.5	-3.2	frz_RAIN
151	Apr-07-99	75%	CLARIANT SAFEWING MP IV 1957	4b	40.0	12.1	-3.2	frz_RAIN
152	Apr-07-99	50%	OCTAGON MAXFLIGHT	4a	13.0	12.4	-3.0	frz_RAIN
153	Apr-07-99	75%	KILFROST ABC-II PLUS	2b	40.0	12.5	-3.2	frz_RAIN

SIMULATED FREEZING DRIZZLE AND LIGHT FRZ RAIN AT CEF FOR 1998-99

Test No.	Date	Fluid Dilution	Fluid Name	Fluid Type	Fail Time [min.]	Rate of precep. [g/dm^{*2}/hr]	Ambient Temp (°C)	Precip Type
154	Apr-07-99	50%	KILFROST ABC-II PLUS	2a	15.0	13.2	-3.0	frz_RAIN
155	Apr-07-99	50%	KILFROST ABC-S	4a	12.0	12.7	-3.0	frz_RAIN
156	Apr-07-99	50%	KILFROST ABC-II PLUS	2a	15.0	12.9	-3.0	frz_RAIN
157	Apr-07-99	50%	KILFROST ABC-S	4a	13.0	12.5	-3.0	frz_RAIN
158	Apr-07-99	Std	UCAR XL54	1	9.3	12.8	-3.1	frz_RAIN
159	Apr-07-99	Std	UCAR XL54	1	9.2	12.8	-3.1	frz_RAIN
160	Apr-07-99	Std	CLARIANT 1938	1	10.0	12.9	-3.1	frz_RAIN
161	Apr-07-99	Std	CLARIANT 1938	1	9.8	12.5	-3.1	frz_RAIN
162	Apr-07-99	Std	INLAND DURAGLY-E	1	9.8	12.1	-3.1	frz_RAIN
163	Apr-07-99	Std	INLAND DURAGLY-E	1	9.7	12.2	-3.1	frz_RAIN
164	Apr-07-99	Std	INLAND DURAGLY-P	1	10.3	12.9	-3.1	frz_RAIN
165	Apr-07-99	Std	INLAND DURAGLY-P	1	10.0	13.2	-3.1	frz_RAIN
166	Apr-13-99	Neat	FLUID X	4	73.0	12.7	-9.9	frz_RAIN
167	Apr-13-99	Neat	KILFROST ABC-S	4	30.0	12.7	-10.0	frz_RAIN
168	Apr-13-99	Neat	OCTAGON MAXFLIGHT	4	43.0	12.6	-9.9	frz_RAIN
169	Apr-13-99	Neat	CLARIANT SAFEWING MP IV 1957	4	34.0	12.8	-9.9	frz_RAIN
170	Apr-13-99	Neat	KILFROST ABC-II PLUS	2	30.0	12.4	-9.9	frz_RAIN
171	Apr-13-99	75%	KILFROST ABC-S	4b	37.0	12.2	-9.9	frz_RAIN
172	Apr-13-99	Neat	UCAR ULTRA +	4	45.0	12.0	-9.9	frz_RAIN
173	Apr-13-99	Neat	KILFROST ABC-S	4	32.0	12.7	-9.9	frz_RAIN
174	Apr-13-99	Neat	FLUID X	4	63.0	12.7	-9.9	frz_RAIN
175	Apr-13-99	Neat	KILFROST ABC-II PLUS	2	32.0	12.5	-10.0	frz_RAIN
176	Apr-13-99	Neat	OCTAGON MAXFLIGHT	4	42.0	12.8	-9.9	frz_RAIN
177	Apr-13-99	Neat	CLARIANT SAFEWING MP IV 1957	4	35.0	12.5	-9.8	frz_RAIN
178	Apr-13-99	75%	CLARIANT SAFEWING MP IV 1957	4b	27.0	12.5	-9.8	frz_RAIN
179	Apr-13-99	75%	OCTAGON MAXFLIGHT	4b	30.0	12.5	-9.9	frz_RAIN
180	Apr-13-99	75%	OCTAGON MAXFLIGHT	4b	32.0	12.1	-9.9	frz_RAIN
181	Apr-13-99	75%	CLARIANT SAFEWING MP IV 1957	4b	34.0	12.0	-9.8	frz_RAIN
182	Apr-13-99	75%	KILFROST ABC-II PLUS	2b	26.0	11.9	-9.8	frz_RAIN
183	Apr-13-99	75%	KILFROST ABC-S	4b	37.0	12.4	-9.9	frz_RAIN
184	Apr-13-99	Neat	UCAR ULTRA +	4	46.0	12.6	-10.1	frz_RAIN
185	Apr-13-99	Std	CLARIANT 1938	1	6.0	12.8	-10.1	frz_RAIN
186	Apr-13-99	Std	INLAND DURAGLY-E	1	5.0	12.9	-10.3	frz_RAIN
187	Apr-13-99	Std	INLAND DURAGLY-P	1	5.0	12.7	-10.2	frz_RAIN
188	Apr-13-99	75%	KILFROST ABC-II PLUS	2b	18.0	12.8	-10.1	frz_RAIN
189	Apr-13-99	75%	KILFROST ABC-II PLUS	2b	16.0	12.4	-10.2	frz_RAIN
190	Apr-13-99	Std	CLARIANT 1938	1	6.0	12.6	-10.1	frz_RAIN
191	Apr-13-99	Std	INLAND DURAGLY-P	1	6.0	12.4	-10.1	frz_RAIN
192	Apr-13-99	Std	UCAR XL54	1	6.0	11.6	-10.0	frz_RAIN
193	Apr-13-99	Std	UCAR XL54	1	6.0	11.8	-10.0	frz_RAIN
194	Apr-13-99	Std	INLAND DURAGLY-E	1	6.0	12.1	-10.2	frz_RAIN
195	Apr-14-99	Neat	FLUID X	4	162.0	4.7	-10.2	frz_drizzle
196	Apr-14-99	Neat	OCTAGON MAXFLIGHT	4	80.0	4.6	-10.2	frz_drizzle
197	Apr-14-99	Neat	FLUID X	4	154.0	5.3	-10.2	frz_drizzle
198	Apr-14-99	Neat	CLARIANT SAFEWING MP IV 1957	4	62.0	4.9	-10.2	frz_drizzle
199	Apr-14-99	Neat	UCAR ULTRA +	4	91.0	4.7	-10.2	frz_drizzle
200	Apr-14-99	Neat	KILFROST ABC-II PLUS	2	44.0	5.1	-10.2	frz_drizzle
201	Apr-14-99	75%	KILFROST ABC-II PLUS	2b	31.0	5.0	-10.1	frz_drizzle
202	Apr-14-99	75%	CLARIANT SAFEWING MP IV 1957	4b	59.0	4.9	-10.1	frz_drizzle
203	Apr-14-99	Neat	OCTAGON MAXFLIGHT	4	77.0	5.1	-10.1	frz_drizzle
204	Apr-14-99	75%	KILFROST ABC-II PLUS	2b	35.0	4.6	-10.1	frz_drizzle

SIMULATED FREEZING DRIZZLE AND LIGHT FRZ RAIN AT CEF FOR 1998-99

Test No.	Date	Fluid Dilution	Fluid Name	Fluid Type	Fail Time [min.]	Rate of precep. [g/dm*^{2}/hr]	Ambient Temp (°C)	Precip Type
205	Apr-14-99	Neat	CLARIANT SAFEWING MP IV 1957	4	64.0	4.6	-10.1	frz_drizzle
206	Apr-14-99	Neat	OCTAGON MAXFLIGHT	4	74.0	4.9	-10.1	frz_drizzle
207	Apr-14-99	Neat	KILFROST ABC-II PLUS	2	42.0	5.3	-10.2	frz_drizzle
208	Apr-14-99	75%	OCTAGON MAXFLIGHT	4b	62.0	4.9	-10.0	frz_drizzle
209	Apr-14-99	75%	OCTAGON MAXFLIGHT	4b	61.0	4.9	-10.0	frz_drizzle
210	Apr-14-99	Neat	UCAR ULTRA +	4	86.0	5.0	-10.1	frz_drizzle
211	Apr-14-99	Neat	KILFROST ABC-S	4	87.0	5.3	-10.0	frz_drizzle
212	Apr-14-99	Neat	KILFROST ABC-S	4	91.0	4.7	-10.0	frz_drizzle
213	Apr-14-99	75%	KILFROST ABC-S	4b	95.0	4.7	-10.0	frz_drizzle
214	Apr-14-99	Neat	KILFROST ABC-S	4	85.0	5.0	-10.0	frz_drizzle
215	Apr-14-99	75%	KILFROST ABC-S	4b	89.0	5.3	-10.0	frz_drizzle
216	Apr-14-99	75%	CLARIANT SAFEWING MP IV 1957	4b	57.0	4.9	-10.0	frz_drizzle
217	Apr-15-99	Neat	UCAR ULTRA +	4	79.0	5.0	-10.1	frz_drizzle
218	Apr-15-99	Neat	CLARIANT SAFEWING MP IV 1957	4	51.0	4.8	-10.1	frz_drizzle
219	Apr-15-99	Neat	CLARIANT SAFEWING MP IV 1957	4	55.0	5.0	-10.1	frz_drizzle
220	Apr-15-99	75%	KILFROST ABC-S	4b	87.0	5.0	-10.1	frz_drizzle
221	Apr-15-99	Neat	UCAR ULTRA +	4	75.0	4.9	-10.1	frz_drizzle
222	Apr-15-99	Std	UCAR XL54	1	9.0	5.0	-10.0	frz_drizzle
223	Apr-15-99	Std	CLARIANT 1938	1	8.3	4.9	-10.0	frz_drizzle
224	Apr-15-99	Std	INLAND DURAGLY-E	1	9.3	4.9	-10.0	frz_drizzle
225	Apr-15-99	Std	INLAND DURAGLY-P	1	8.3	4.8	-10.0	frz_drizzle
226	Apr-15-99	Std	UCAR XL54	1	8.9	4.9	-10.0	frz_drizzle
227	Apr-15-99	Std	CLARIANT 1938	1	8.0	4.8	-10.0	frz_drizzle
228	Apr-15-99	Std	INLAND DURAGLY-E	1	8.1	4.7	-10.0	frz_drizzle
229	Apr-15-99	Std	INLAND DURAGLY-P	1	8.4	4.9	-10.0	frz_drizzle
230	Apr-15-99	Neat	CLARIANT SAFEWING MP IV 1957	4	38.0	12.8	-10.0	frz_drizzle
231	Apr-15-99	Neat	KILFROST ABC-II PLUS	2	13.0	12.8	-10.0	frz_drizzle
232	Apr-15-99	75%	KILFROST ABC-S	4b	20.0	12.8	-10.0	frz_drizzle
233	Apr-15-99	75%	KILFROST ABC-II PLUS	2b	15.0	12.5	-10.0	frz_drizzle
234	Apr-15-99	75%	OCTAGON MAXFLIGHT	4b	21.0	13.0	-10.0	frz_drizzle
235	Apr-15-99	75%	CLARIANT SAFEWING MP IV 1957	4b	22.0	13.4	-10.0	frz_drizzle
236	Apr-15-99	Neat	UCAR ULTRA +	4	39.0	13.3	-10.0	frz_drizzle
237	Apr-15-99	Neat	KILFROST ABC-II PLUS	2	15.0	13.4	-10.0	frz_drizzle
238	Apr-15-99	75%	CLARIANT SAFEWING MP IV 1957	4b	21.0	13.5	-10.0	frz_drizzle
239	Apr-16-99	Neat	UCAR ULTRA +	4	28.0	24.5	-10.0	frz_RAIN
240	Apr-16-99	Neat	KILFROST ABC-S	4	11.0	25.1	-10.1	frz_RAIN
241	Apr-16-99	Neat	OCTAGON MAXFLIGHT	4	14.0	25.1	-10.1	frz_RAIN
242	Apr-16-99	Neat	CLARIANT SAFEWING MP IV 1957	4	20.0	25.4	-10.0	frz_RAIN
243	Apr-16-99	Neat	KILFROST ABC-II PLUS	2	9.0	25.2	-10.1	frz_RAIN
244	Apr-16-99	Neat	UCAR ULTRA +	4	29.0	25.0	-10.0	frz_RAIN
245	Apr-16-99	Neat	KILFROST ABC-S	4	11.0	25.0	-10.1	frz_RAIN
246	Apr-16-99	Neat	OCTAGON MAXFLIGHT	4	15.0	25.0	-10.1	frz_RAIN
247	Apr-16-99	Neat	CLARIANT SAFEWING MP IV 1957	4	20.0	25.0	-10.0	frz_RAIN
248	Apr-16-99	Neat	FLUID X	4	26.0	25.0	-10.0	frz_RAIN
249	Apr-16-99	Neat	FLUID X	4	24.0	24.8	-10.0	frz_RAIN
250	Apr-16-99	75%	OCTAGON MAXFLIGHT	4b	14.0	24.5	-10.1	frz_RAIN
251	Apr-16-99	Neat	KILFROST ABC-II PLUS	2	14.0	24.8	-10.1	frz_RAIN
252	Apr-16-99	75%	OCTAGON MAXFLIGHT	4b	14.0	24.8	-10.1	frz_RAIN
253	Apr-16-99	Neat	KILFROST ABC-II PLUS	2	10.0	25.0	-10.1	frz_RAIN
254	Apr-16-99	75%	CLARIANT SAFEWING MP IV 1957	4b	15.0	25.1	-10.1	frz_RAIN
255	Apr-16-99	75%	KILFROST ABC-S	4b	10.0	25.0	-10.1	frz_RAIN

SIMULATED FREEZING DRIZZLE AND LIGHT FRZ RAIN AT CEF FOR 1998-99

Test No.	Date	Fluid Dilution	Fluid Name	Fluid Type	Fail Time [min.]	Rate of precep. [g/dm²/hr]	Ambient Temp (°C)	Precip Type
256	Apr-16-99	75%	CLARIANT SAFEWING MP IV 1957	4b	15.0	24.2	-10.1	frz_RAIN
257	Apr-16-99	75%	KILFROST ABC-II PLUS	2b	9.0	24.4	-10.1	frz_RAIN
258	Apr-16-99	75%	KILFROST ABC-S	4b	11.0	24.5	-10.1	frz_RAIN
259	Apr-16-99	75%	KILFROST ABC-II PLUS	2b	10.0	24.8	-10.1	frz_RAIN
260	Apr-16-99	Neat	UCAR ULTRA +	4	27.0	24.5	-10.1	frz_RAIN
261	Apr-16-99	Neat	UCAR ULTRA +	4	29.0	23.9	-10.1	frz_RAIN
262	Apr-16-99	Neat	CLARIANT SAFEWING MP IV 1957	4	21.0	24.4	-10.0	frz_RAIN
263	Apr-16-99	Neat	CLARIANT SAFEWING MP IV 1957	4	22.0	24.0	-10.0	frz_RAIN
264	Apr-16-99	Std	UCAR XL54	1	4.0	24.5	-10.1	frz_RAIN
265	Apr-16-99	Std	CLARIANT 1938	1	4.1	24.6	-10.1	frz_RAIN
266	Apr-16-99	Std	INLAND DURAGLY-E	1	3.9	25.4	-10.1	frz_RAIN
267	Apr-16-99	Std	INLAND DURAGLY-E	1	3.8	25.1	-10.1	frz_RAIN
268	Apr-16-99	Std	INLAND DURAGLY-P	1	4.4	24.0	-10.1	frz_RAIN
269	Apr-16-99	Std	INLAND DURAGLY-P	1	4.2	24.3	-10.1	frz_RAIN
270	Apr-28-99	Neat	UCAR ULTRA +	4	100.0	4.9	-9.9	frz_drizzle
271	Apr-28-99	Neat	UCAR ULTRA +	4	100.0	4.9	-9.9	frz_drizzle
272	Apr-28-99	Neat	UCAR ULTRA +	4	85.0	5.3	-9.9	frz_drizzle
273	Apr-28-99	Neat	UCAR ULTRA +	4	78.0	5.5	-9.9	frz_drizzle
274	Apr-28-99	Neat	OCTAGON MAXFLIGHT	4	29.0	12.5	-10.3	frz_drizzle
275	Apr-28-99	Neat	FLUID X	4	71.0	12.4	-10.0	frz_drizzle
276	Apr-28-99	Neat	UCAR ULTRA +	4	48.0	12.6	-10.1	frz_drizzle
277	Apr-28-99	Neat	KILFROST ABC-S	4	20.0	12.6	-10.3	frz_drizzle
278	Apr-28-99	Neat	CLARIANT SAFEWING MP IV 1957	4	35.0	13.3	-10.2	frz_drizzle
279	Apr-28-99	Neat	KILFROST ABC-S	4	20.0	13.4	-10.3	frz_drizzle
280	Apr-28-99	Neat	FLUID X	4	67.0	13.7	-10.0	frz_drizzle
281	Apr-28-99	Std	UCAR XL54	1	5.5	12.5	-9.9	frz_drizzle
282	Apr-28-99	Std	INLAND DURAGLY-E	1	5.9	12.6	-10.1	frz_drizzle
283	Apr-28-99	Std	INLAND DURAGLY-P	1	5.8	13.4	-10.0	frz_drizzle
284	Apr-28-99	Std	CLARIANT 1938	1	4.8	13.5	-9.9	frz_drizzle
285	Apr-28-99	Neat	OCTAGON MAXFLIGHT	4	28.0	11.2	-9.9	frz_drizzle
286	Apr-28-99	Neat	KILFROST ABC-II PLUS	2	17.0	12.2	-9.7	frz_drizzle
287	Apr-28-99	75%	KILFROST ABC-II PLUS	2b	17.0	12.4	-9.9	frz_drizzle
288	Apr-28-99	75%	KILFROST ABC-S	4b	20.0	12.6	-9.9	frz_drizzle
289	Apr-28-99	75%	OCTAGON MAXFLIGHT	4b	23.0	12.6	-9.9	frz_drizzle
290	Apr-28-99	Neat	UCAR ULTRA +	4	44.0	13.1	-9.8	frz_drizzle
291	Apr-28-99	Neat	UCAR ULTRA +	4	41.0	13.0	-9.8	frz_drizzle
292	Apr-29-99	75%	OCTAGON MAXFLIGHT	4b	74.0	4.7	-2.9	frz_drizzle
293	Apr-29-99	75%	OCTAGON MAXFLIGHT	4b	89.0	5.3	-2.9	frz_drizzle
294	Apr-29-99	Neat	OCTAGON MAXFLIGHT	4	95.0	5.6	-2.9	frz_drizzle
295	Apr-29-99	Neat	OCTAGON MAXFLIGHT	4	110.0	5.7	-2.9	frz_drizzle
296	Apr-29-99	Neat	KILFROST ABC-S	4	129.0	12.4	-2.9	frz_drizzle
297	Apr-29-99	Neat	KILFROST ABC-S	4	130.0	12.8	-2.9	frz_drizzle
298	Apr-29-99	Neat	UCAR ULTRA +	4	46.0	13.6	-2.9	frz_drizzle

SIMULATED FREEZING DRIZZLE AND LIGHT FRZ RAIN at CEF FOR 1998-99 SPECIAL HOLDOVER TIME TESTS (TYPE IV OVER TYPE I)

Test No.	Date	Stand No.	Fluid Name 1	Fluid Name 2	Fluid Dilution	Fluid Type	fail time [min.]	Rate of precep. g/dm*2/hr	Ambient Temp [C]	Precip Type
1	Mar-30-99	1	UCAR ULTRA +	INLAND DURAGLY-E	NEAT/Std	4/0	88.0	4.3	-3.0	frz_drizzle
2	Mar-30-99	1	UCAR ULTRA +	INLAND DURAGLY-P	NEAT/Std	4/0	109.0	4.0	-3.0	frz_drizzle
3	Mar-30-99	1	UCAR ULTRA +	UCAR XL54	NEAT/Std	4/1	105.0	3.9	-3.0	frz_drizzle
4	Mar-30-99	1	CLARIANT SAFEWING 1957	INLAND DURAGLY-E	NEAT/Std	4/0	57.0	5.3	-3.0	frz_drizzle
5	Mar-30-99	1	CLARIANT SAFEWING 1957	INLAND DURAGLY-P	NEAT/Std	4/0	63.0	5.2	-3.0	frz_drizzle
6	Mar-30-99	1	CLARIANT SAFEWING 1957	CLARIANT 1938	NEAT/Std	4/1	67.0	5.2	-3.0	frz_drizzle
7	Mar-31-99	1	UCAR ULTRA +	INLAND DURAGLY-E	NEAT/Std	4/0	80.0	5.1	-3.0	frz_drizzle
8	Mar-31-99	1	UCAR ULTRA +	INLAND DURAGLY-P	NEAT/Std	4/0	82.0	5.1	-3.0	frz_drizzle
9	Mar-31-99	1	UCAR ULTRA +	UCAR XL54	NEAT/Std	4/1	88.0	5.1	-3.0	frz_drizzle
10	Mar-31-99	1	CLARIANT SAFEWING 1957	INLAND DURAGLY-E	NEAT/Std	4/0	55.0	5.4	-3.0	frz_drizzle
11	Mar-31-99	1	CLARIANT SAFEWING 1957	INLAND DURAGLY-P	NEAT/Std	4/0	57.0	5.3	-3.0	frz_drizzle
12	Mar-31-99	1	CLARIANT SAFEWING 1957	UCAR XL54	NEAT/Std	4/1	57.0	5.3	-3.0	frz_drizzle
13	Mar-31-99	1	CLARIANT 1938	INLAND DURAGLY-E	Std/Std	1/0	14.4	4.5	-3.0	frz_drizzle
14	Mar-31-99	1	CLARIANT 1938	INLAND DURAGLY-P	Std/Std	1/0	15.3	4.2	-3.0	frz_drizzle
15	Mar-31-99	1	CLARIANT 1938	INLAND DURAGLY-P	Std/Std	1/0	15.7	3.8	-3.0	frz_drizzle
16	Mar-31-99	1	CLARIANT 1938	INLAND DURAGLY-E	Std/Std	1/0	11.3	5.5	-3.0	frz_drizzle
17	Mar-31-99	1	UCAR XL54	INLAND DURAGLY-E	Std/Std	1/0	13.2	4.4	-3.0	frz_drizzle
18	Mar-31-99	1	UCAR XL54	INLAND DURAGLY-E	Std/Std	1/0	10.7	5.7	-3.0	frz_drizzle
19	Mar-31-99	1	UCAR XL54	INLAND DURAGLY-P	Std/Std	1/0	11.8	5.5	-3.0	frz_drizzle
20	Mar-31-99	1	UCAR XL54	INLAND DURAGLY-P	Std/Std	1/0	12.5	5.0	-3.0	frz_drizzle
21	Apr-06-99	1	UCAR ULTRA +	UCAR XL54	NEAT/Std	4/1	25.0	24.7	-3.0	FRZ_RAIN
22	Apr-06-99	1	UCAR ULTRA +	INLAND DURAGLY-E	NEAT/Std	4/0	24.0	24.4	-3.0	FRZ_RAIN
23	Apr-06-99	1	UCAR ULTRA +	INLAND DURAGLY-P	NEAT/Std	4/0	24.0	24.5	-3.0	FRZ_RAIN
24	Apr-06-99	1	CLARIANT SAFEWING 1957	INLAND DURAGLY-E	NEAT/Std	4/0	26.0	24.2	-3.0	FRZ_RAIN
25	Apr-06-99	1	CLARIANT SAFEWING 1957	CLARIANT 1938	NEAT/Std	4/1	26.0	24.8	-3.0	FRZ_RAIN
26	Apr-06-99	1	CLARIANT SAFEWING 1957	INLAND DURAGLY-P	NEAT/Std	4/0	24.0	24.4	-3.0	FRZ_RAIN
27	Apr-06-99	1	CLARIANT SAFEWING 1957	INLAND DURAGLY-E	NEAT/Std	4/0	26.0	24.4	-3.0	FRZ_RAIN
28	Apr-06-99	1	CLARIANT SAFEWING 1957	INLAND DURAGLY-P	NEAT/Std	4/0	25.0	24.8	-3.0	FRZ_RAIN
29	Apr-06-99	1	CLARIANT SAFEWING 1957	CLARIANT 1938	NEAT/Std	4/1	27.0	24.5	-3.0	FRZ_RAIN
30	Apr-06-99	1	UCAR ULTRA +	INLAND DURAGLY-E	NEAT/Std	4/0	23.0	24.2	-3.0	FRZ_RAIN
31	Apr-06-99	1	UCAR ULTRA +	INLAND DURAGLY-P	NEAT/Std	4/0	23.0	24.7	-3.0	FRZ_RAIN
32	Apr-06-99	1	UCAR ULTRA +	UCAR XL54	NEAT/Std	4/1	24.0	24.7	-3.0	FRZ_RAIN
33	Apr-06-99	1	UCAR XL54	INLAND DURAGLY-E	Std/Std	1/0	7.4	24.7	-3.0	FRZ_RAIN
34	Apr-06-99	1	UCAR XL54	INLAND DURAGLY-E	Std/Std	1/0	7.1	24.6	-3.0	FRZ_RAIN
35	Apr-06-99	1	UCAR XL54	INLAND DURAGLY-P	Std/Std	1/0	8.0	24.6	-3.0	FRZ_RAIN
36	Apr-06-99	1	UCAR XL54	INLAND DURAGLY-P	Std/Std	1/0	8.3	24.9	-3.0	FRZ_RAIN
37	Apr-06-99	1	CLARIANT 1938	INLAND DURAGLY-E	Std/Std	1/0	8.5	24.6	-3.0	FRZ_RAIN
38	Apr-06-99	1	CLARIANT 1938	INLAND DURAGLY-E	Std/Std	1/0	10.0	24.3	-3.0	FRZ_RAIN
39	Apr-06-99	1	CLARIANT 1938	INLAND DURAGLY-P	Std/Std	1/0	9.7	24.2	-3.0	FRZ_RAIN
40	Apr-06-99	1	CLARIANT 1938	INLAND DURAGLY-P	Std/Std	1/0	8.1	24.1	-3.0	FRZ_RAIN

SIMULATED FREEZING DRIZZLE AND LIGHT FRZ RAIN at CEF FOR 1998-99 SPECIAL HOLDOVER TIME TESTS (TYPE IV OVER TYPE I)

Test No.	Date	Stand No.	Fluid Name 1	Fluid Name 2	Fluid Dilution	Fluid Type	fail time [min.]	Rate of precep. g/dm*2/hr	Ambient Temp [C]	Precip Type
41	Apr-15-99	1	UCAR ULTRA +	UCAR XL54	NEAT/Std	4/1	78.0	5.1	-10.0	frz_drizzle
42	Apr-15-99	1	UCAR ULTRA +	INLAND DURAGLY-E	NEAT/Std	4/0	69.0	4.9	-10.0	frz_drizzle
43	Apr-15-99	1	UCAR ULTRA +	INLAND DURAGLY-P	NEAT/Std	4/0	63.0	5.1	-10.0	frz_drizzle
44	Apr-15-99	1	CLARIANT SAFEWING 1957	CLARIANT 1938	NEAT/Std	4/1	53.0	4.7	-10.0	frz_drizzle
45	Apr-15-99	1	CLARIANT SAFEWING 1957	INLAND DURAGLY-E	NEAT/Std	4/0	48.0	4.8	-10.0	frz_drizzle
46	Apr-15-99	1	CLARIANT SAFEWING 1957	INLAND DURAGLY-P	NEAT/Std	4/0	51.0	5.0	-10.0	frz_drizzle
47	Apr-15-99	1	CLARIANT SAFEWING 1957	CLARIANT 1938	NEAT/Std	4/1	51.0	4.9	-10.0	frz_drizzle
48	Apr-15-99	1	CLARIANT SAFEWING 1957	INLAND DURAGLY-E	NEAT/Std	4/0	50.0	4.9	-10.0	frz_drizzle
49	Apr-15-99	1	CLARIANT SAFEWING 1957	INLAND DURAGLY-P	NEAT/Std	4/0	50.0	5.0	-10.0	frz_drizzle
50	Apr-15-99	1	UCAR ULTRA +	UCAR XL54	NEAT/Std	4/1	71.0	4.8	-10.0	frz_drizzle
51	Apr-15-99	1	UCAR ULTRA +	INLAND DURAGLY-E	NEAT/Std	4/0	74.0	4.9	-10.0	frz_drizzle
52	Apr-15-99	1	UCAR ULTRA +	INLAND DURAGLY-P	NEAT/Std	4/0	69.0	5.1	-10.0	frz_drizzle
53	Apr-15-99	1	UCAR XL54	INLAND DURAGLY-E	Std/Std	1/0	8.8	5.1	-10.0	frz_drizzle
54	Apr-15-99	1	UCAR XL54	INLAND DURAGLY-E	Std/Std	1/0	9.3	5.0	-10.0	frz_drizzle
55	Apr-15-99	1	UCAR XL54	INLAND DURAGLY-P	Std/Std	1/0	9.4	4.8	-10.0	frz_drizzle
56	Apr-15-99	1	UCAR XL54	INLAND DURAGLY-P	Std/Std	1/0	9.7	4.9	-10.0	frz_drizzle
57	Apr-15-99	1	CLARIANT 1938	INLAND DURAGLY-P	Std/Std	1/0	8.3	5.0	-10.0	frz_drizzle
58	Apr-15-99	1	CLARIANT 1938	INLAND DURAGLY-P	Std/Std	1/0	8.0	4.7	-10.0	frz_drizzle
59	Apr-15-99	1	CLARIANT 1938	INLAND DURAGLY-E	Std/Std	1/0	8.2	4.7	-10.0	frz_drizzle
60	Apr-15-99	1	CLARIANT 1938	INLAND DURAGLY-E	Std/Std	1/0	8.2	4.7	-10.0	frz_drizzle
61	Apr-16-99	1	UCAR ULTRA +	UCAR XL54	NEAT/Std	4/1	25.0	25.0	-10.0	FRZ_RAIN
62	Apr-16-99	1	UCAR ULTRA +	INLAND DURAGLY-P	NEAT/Std	4/0	23.0	25.2	-10.0	FRZ_RAIN
63	Apr-16-99	1	UCAR ULTRA +	INLAND DURAGLY-E	NEAT/Std	4/0	23.0	24.8	-10.0	FRZ_RAIN
64	Apr-16-99	1	UCAR ULTRA +	INLAND DURAGLY-E	NEAT/Std	4/0	25.0	24.3	-10.0	FRZ_RAIN
65	Apr-16-99	1	UCAR ULTRA +	UCAR XL54	NEAT/Std	4/1	25.0	24.4	-10.0	FRZ_RAIN
66	Apr-16-99	1	UCAR ULTRA +	INLAND DURAGLY-P	NEAT/Std	4/0	25.0	24.9	-10.0	FRZ_RAIN
67	Apr-16-99	1	CLARIANT SAFEWING 1957	CLARIANT 1938	NEAT/Std	4/1	21.0	25.2	-10.0	FRZ_RAIN
68	Apr-16-99	1	CLARIANT SAFEWING 1957	INLAND DURAGLY-E	NEAT/Std	4/0	19.0	25.0	-10.0	FRZ_RAIN
69	Apr-16-99	1	CLARIANT SAFEWING 1957	INLAND DURAGLY-P	NEAT/Std	4/0	19.0	24.8	-10.0	FRZ_RAIN
70	Apr-16-99	1	CLARIANT SAFEWING 1957	INLAND DURAGLY-E	NEAT/Std	4/0	20.0	24.3	-10.0	FRZ_RAIN
71	Apr-16-99	1	CLARIANT SAFEWING 1957	CLARIANT 1938	NEAT/Std	4/1	20.0	24.4	-10.0	FRZ_RAIN
72	Apr-16-99	1	CLARIANT SAFEWING 1957	INLAND DURAGLY-P	NEAT/Std	4/0	19.0	24.5	-10.0	FRZ_RAIN
73	Apr-16-99	1	UCAR XL54	INLAND DURAGLY-E	Std/Std	1/0	4.5	24.5	-10.0	FRZ_RAIN
74	Apr-16-99	1	UCAR XL54	INLAND DURAGLY-E	Std/Std	1/0	4.7	24.6	-10.0	FRZ_RAIN
75	Apr-16-99	1	UCAR XL54	INLAND DURAGLY-P	Std/Std	1/0	4.3	25.4	-10.0	FRZ_RAIN
76	Apr-16-99	1	UCAR XL54	INLAND DURAGLY-P	Std/Std	1/0	4.6	25.1	-10.0	FRZ_RAIN
77	Apr-16-99	1	CLARIANT 1938	INLAND DURAGLY-E	Std/Std	1/0	4.7	24.0	-10.0	FRZ_RAIN
78	Apr-16-99	1	CLARIANT 1938	INLAND DURAGLY-E	Std/Std	1/0	4.6	24.3	-10.0	FRZ_RAIN
79	Apr-16-99	1	CLARIANT 1938	INLAND DURAGLY-P	Std/Std	1/0	4.3	24.0	-10.0	FRZ_RAIN
80	Apr-16-99	1	CLARIANT 1938	INLAND DURAGLY-P	Std/Std	1/0	4.7	24.7	-10.0	FRZ_RAIN

SIMULATED FREEZING DRIZZLE AND LIGHT FRZ RAIN AT CEF FOR 1998-9
SPECIAL HOLDOVER TIME TESTS (NON-SHEARED FLUIDS)

Test No.	Date	Fluid Name	Fluid Dilution	Fluid Type	Fail Time [min.]	Rate of precep. [g/dm*^{2}/hr]	Ambient Temp (°C)	Precip Type
1	Mar-29-99	CLARIANT SAFEWING MP IV 1957	neat	4	94.0	4.9	-3.4	frz_drizzle
2	Mar-29-99	OCTAGON MAXFLIGHT	Neat	4	130.0	4.9	-3.4	frz_drizzle
3	Mar-29-99	KILFROST ABC-II PLUS	Neat	4	76.0	5.5	-3.4	frz_drizzle
4	Mar-30-99	KILFROST ABC-S	Neat	4	153.0	5.3	-3.3	frz_drizzle
5	Mar-30-99	CLARIANT SAFEWING MP IV 1957	Neat	4	139.0	5.0	-3.4	frz_drizzle
6	Mar-30-99	KILFROST ABC-II PLUS	Neat	4	84.0	5.5	-3.4	frz_drizzle
7	Mar-30-99	KILFROST ABC-S	Neat	4	114.0	6.1	-3.3	frz_drizzle
8	Mar-31-99	CLARIANT SAFEWING MP IV 1957	NEAT	4	109.0	5.0	-3.0	frz_drizzle
9	Mar-31-99	OCTAGON MAXFLIGHT	neat	4	157.0	5.2	-3.0	frz_drizzle
10	Apr-06-99	KILFROST ABC-S	Neat	4	86.0	25.0	-2.9	frz_RAIN
11	Apr-06-99	KILFROST ABC-II PLUS	Neat	4	28.0	25.3	-2.8	frz_RAIN
12	Apr-06-99	OCTAGON MAXFLIGHT	Neat	4	50.0	24.8	-2.8	frz_RAIN
13	Apr-06-99	CLARIANT SAFEWING MP IV 1957	Neat	4	53.0	24.2	-2.7	frz_RAIN
14	Apr-06-99	OCTAGON MAXFLIGHT	Neat	4	45.0	24.6	-2.7	frz_RAIN
15	Apr-06-99	CLARIANT SAFEWING MP IV 1957	Neat	4	47.0	24.9	-2.7	frz_RAIN
16	Apr-06-99	KILFROST ABC-S	Neat	4	75.0	24.0	-3.0	frz_RAIN
17	Apr-06-99	KILFROST ABC-II PLUS	Neat	4	30.0	24.9	-2.8	frz_RAIN
18	Apr-14-99	KILFROST ABC-S	Neat	4	78.0	4.9	-10.2	frz_drizzle
19	Apr-14-99	KILFROST ABC-II PLUS	Neat	4	53.0	5.0	-10.0	frz_drizzle
20	Apr-14-99	OCTAGON MAXFLIGHT	Neat	4	82.0	5.0	-10.0	frz_drizzle
21	Apr-14-99	CLARIANT SAFEWING MP IV 1957	Neat	4	84.0	5.2	-10.0	frz_drizzle
22	Apr-14-99	CLARIANT SAFEWING MP IV 1957	Neat	4	85.0	4.7	-10.0	frz_drizzle
23	Apr-14-99	KILFROST ABC-II PLUS	Neat	4	57.0	5.0	-10.0	frz_drizzle
24	Apr-15-99	CLARIANT SAFEWING MP IV 1957	Neat	4	83.0	5.1	-10.1	frz_drizzle
25	Apr-16-99	KILFROST ABC-S	Neat	4	14.0	24.9	-10.0	frz_RAIN
26	Apr-16-99	OCTAGON MAXFLIGHT	Neat	4	15.0	24.9	-10.1	frz_RAIN
27	Apr-16-99	KILFROST ABC-II PLUS	Neat	4	14.0	25.3	-10.0	frz_RAIN
28	Apr-16-99	OCTAGON MAXFLIGHT	Neat	4	16.0	25.0	-10.0	frz_RAIN
29	Apr-16-99	CLARIANT SAFEWING MP IV 1957	Neat	4	22.0	25.2	-10.0	frz_RAIN
30	Apr-16-99	KILFROST ABC-S	Neat	4	14.0	24.6	-10.0	frz_RAIN
31	Apr-16-99	CLARIANT SAFEWING MP IV 1957	Neat	4	22.0	25.1	-10.1	frz_RAIN

SIMULATED FREEZING FOG AT CEF FOR 1998-99

Test No.	Date	Fluid Name	Fluid Dilution	Fluid Type	Fail Time [min.]	Rate of precep. [g/dm*²/hr]	Ambient Temp (°C)	Precip Type
1	Apr-08-99	KILFROST ABC-II PLUS	neat	2	70.0	4.6	-3.1	frz_fog
2	Apr-08-99	OCTAGON MAXFLIGHT	50%	4a	27.0	5.1	-3.2	frz_fog
3	Apr-08-99	KILFROST ABC-S	75%	4b	64.0	5.1	-3.1	frz_fog
4	Apr-08-99	KILFROST ABC-S	Neat	4	146.0	5.2	-3.0	frz_fog
5	Apr-08-99	OCTAGON MAXFLIGHT	Neat	4	133.0	5.0	-3.0	frz_fog
6	Apr-08-99	CLARIANT SAFEWING MP IV 1957	75%	4b	75.0	4.4	-3.1	frz_fog
7	Apr-08-99	KILFROST ABC-II PLUS	50%	2a	13.0	5.1	-3.2	frz_fog
8	Apr-08-99	FLUID X	Neat	4	161.0	5.2	-2.9	frz_fog
9	Apr-08-99	CLARIANT SAFEWING MP IV 1957	Neat	4	66.0	5.2	-3.1	frz_fog
10	Apr-08-99	FLUID X	Neat	4	168.0	4.7	-3.0	frz_fog
11	Apr-08-99	KILFROST ABC-S	Neat	4	180.0	4.4	-3.0	frz_fog
12	Apr-08-99	OCTAGON MAXFLIGHT	Neat	4	153.0	4.1	-3.0	frz_fog
13	Apr-08-99	CLARIANT SAFEWING MP IV 1957	Neat	4	67.0	4.6	-2.9	frz_fog
14	Apr-08-99	OCTAGON MAXFLIGHT	75%	4b	101.0	4.6	-2.9	frz_fog
15	Apr-08-99	UCAR ULTRA +	Neat	4	91.0	4.6	-2.9	frz_fog
16	Apr-08-99	KILFROST ABC-II PLUS	Neat	2	74.0	5.1	-3.2	frz_fog
17	Apr-08-99	OCTAGON MAXFLIGHT	50%	4a	32.0	4.5	-2.8	frz_fog
18	Apr-08-99	OCTAGON MAXFLIGHT	75%	4b	79.0	4.5	-2.9	frz_fog
19	Apr-08-99	UCAR ULTRA +	Neat	4	102.0	5.4	-2.9	frz_fog
20	Apr-08-99	CLARIANT SAFEWING MP IV 1957	50%	4a	25.0	5.4	-3.1	frz_fog
21	Apr-08-99	KILFROST ABC-II PLUS	50%	2a	13.0	5.2	-3.2	frz_fog
22	Apr-08-99	CLARIANT SAFEWING MP IV 1957	50%	4a	24.0	5.3	-3.1	frz_fog
23	Apr-08-99	CLARIANT SAFEWING MP IV 1957	75%	4b	66.0	5.3	-3.1	frz_fog
24	Apr-08-99	KILFROST ABC-II PLUS	75%	2b	74.0	5.1	-3.1	frz_fog
25	Apr-08-99	OCTAGON MAXFLIGHT	75%	4b	90.0	5.4	-3.0	frz_fog
26	Apr-08-99	KILFROST ABC-II PLUS	75%	2b	64.0	5.3	-2.9	frz_fog
27	Apr-08-99	CLARIANT 1938	Std	1	16.0	3.5	-2.7	frz_fog
28	Apr-08-99	UCAR XL54	Std	1	15.9	3.7	-2.7	frz_fog
29	Apr-08-99	INLAND DURAGLY-E	Std	1	15.3	3.7	-2.7	frz_fog
30	Apr-08-99	KILFROST ABC-S	50%	4a	24.0	3.8	-2.7	frz_fog
31	Apr-08-99	KILFROST ABC-S	50%	4a	25.0	3.9	-2.7	frz_fog
32	Apr-08-99	INLAND DURAGLY-E	Std	1	15.5	3.5	-2.7	frz_fog
33	Apr-08-99	INLAND DURAGLY-P	Std	1	14.8	3.6	-2.7	frz_fog
34	Apr-08-99	INLAND DURAGLY-P	Std	1	14.6	3.5	-2.7	frz_fog
35	Apr-08-99	KILFROST ABC-S	75%	4b	63.0	4.7	-2.8	frz_fog
36	Apr-09-99	OCTAGON MAXFLIGHT	50%	4a	50.0	1.8	-3.1	frz_fog
37	Apr-09-99	KILFROST ABC-II PLUS	50%	2a	55.0	1.7	-3.1	frz_fog
38	Apr-09-99	KILFROST ABC-S	neat	4	287.0	1.9	-3.0	frz_fog
39	Apr-09-99	FLUID X	neat	4	274.0	2.0	-3.0	frz_fog
40	Apr-09-99	OCTAGON MAXFLIGHT	neat	4	248.0	2.1	-3.0	frz_fog
41	Apr-09-99	KILFROST ABC-S	neat	4	313.0	2.2	-3.1	frz_fog
42	Apr-09-99	FLUID X	neat	4	278.0	1.8	-3.0	frz_fog
43	Apr-09-99	KILFROST ABC-II PLUS	neat	2	152.0	2.0	-3.0	frz_fog
44	Apr-09-99	CLARIANT SAFEWING MP IV 1957	neat	4	137.0	2.0	-3.0	frz_fog
45	Apr-09-99	CLARIANT SAFEWING MP IV 1957	50%	4a	53.0	1.8	-2.9	frz_fog
46	Apr-09-99	UCAR ULTRA +	Neat	4	266.0	1.9	-3.0	frz_fog

SIMULATED FREEZING FOG AT CEF FOR 1998-99

Test No.	Date	Fluid Name	Fluid Dilution	Fluid Type	Fail Time [min.]	Rate of precep. [g/dm²/hr]	Ambient Temp (°C)	Precip Type
47	Apr-09-99	KILFROST ABC-S	50%	4a	35.0	2.0	-3.3	frz_fog
48	Apr-09-99	KILFROST ABC-II PLUS	50%	2a	47.0	2.0	-3.3	frz_fog
49	Apr-09-99	KILFROST ABC-S	50%	4a	35.0	1.8	-3.1	frz_fog
50	Apr-09-99	OCTAGON MAXFLIGHT	50%	4a	53.0	2.0	-3.3	frz_fog
51	Apr-09-99	INLAND DURAGLY-P	Std	1	21.0	2.0	-3.1	frz_fog
52	Apr-09-99	CLARIANT 1938	Std	1	21.0	2.2	-3.1	frz_fog
53	Apr-09-99	INLAND DURAGLY-E	Std	1	17.5	2.1	-3.2	frz_fog
54	Apr-09-99	INLAND DURAGLY-E	Std	1	18.4	2.2	-3.1	frz_fog
55	Apr-09-99	CLARIANT SAFEWING MP IV 1957	50%	4a	48.0	2.1	-3.1	frz_fog
56	Apr-09-99	UCAR XL54	Std	1	20.8	2.2	-3.1	frz_fog
57	Apr-09-99	INLAND DURAGLY-P	Std	1	19.2	2.1	-3.1	frz_fog
58	Apr-12-99	CLARIANT SAFEWING MP IV 1957	Neat	4	142.0	1.8	-3.1	frz_fog
59	Apr-12-99	KILFROST ABC-II PLUS	Neat	2	136.0	2.1	-3.1	frz_fog
60	Apr-12-99	KILFROST ABC-II PLUS	75%	2b	141.0	2.2	-3.1	frz_fog
61	Apr-12-99	UCAR ULTRA +	Neat	4	184.0	2.0	-3.1	frz_fog
62	Apr-12-99	KILFROST ABC-S	75%	4b	120.0	1.8	-3.1	frz_fog
63	Apr-12-99	OCTAGON MAXFLIGHT	75%	4b	185.0	2.0	-3.1	frz_fog
64	Apr-12-99	OCTAGON MAXFLIGHT	Neat	4	219.0	2.1	-3.1	frz_fog
65	Apr-12-99	KILFROST ABC-II PLUS	75%	2b	149.0	1.8	-3.0	frz_fog
66	Apr-12-99	OCTAGON MAXFLIGHT	75%	4b	176.0	1.7	-3.1	frz_fog
67	Apr-12-99	KILFROST ABC-S	75%	4b	114.0	1.6	-3.0	frz_fog
68	Apr-12-99	CLARIANT SAFEWING MP IV 1957	75%	4b	146.0	1.9	-3.1	frz_fog
69	Apr-12-99	CLARIANT SAFEWING MP IV 1957	75%	4b	133.0	1.7	-3.0	frz_fog
70	Apr-12-99	KILFROST ABC-II PLUS	Neat	2	157.0	1.8	-3.0	frz_fog
71	Apr-22-99	UCAR ULTRA +	Neat	4	193.0	1.8	-13.9	frz_fog
72	Apr-22-99	CLARIANT SAFEWING MP IV 1957	75%	4b	80.0	1.9	-13.5	frz_fog
73	Apr-22-99	KILFROST ABC-II PLUS	Neat	2	72.0	1.7	-13.5	frz_fog
74	Apr-22-99	FLUID X	Neat	4	258.0	1.6	-14.0	frz_fog
75	Apr-22-99	KILFROST ABC-II PLUS	75%	2b	58.0	1.9	-13.5	frz_fog
76	Apr-22-99	FLUID X	Neat	4	239.0	1.9	-14.0	frz_fog
77	Apr-22-99	OCTAGON MAXFLIGHT	Neat	4	133.0	2.0	-13.8	frz_fog
78	Apr-22-99	KILFROST ABC-S	Neat	4	132.0	1.9	-13.8	frz_fog
79	Apr-22-99	KILFROST ABC-II PLUS	Neat	2	76.0	1.7	-13.6	frz_fog
80	Apr-22-99	KILFROST ABC-S	Neat	4	143.0	1.8	-14.3	frz_fog
81	Apr-22-99	OCTAGON MAXFLIGHT	75%	4b	68.0	1.9	-14.4	frz_fog
82	Apr-22-99	CLARIANT SAFEWING MP IV 1957	Neat	4	96.0	1.8	-14.1	frz_fog
83	Apr-22-99	UCAR ULTRA +	Neat	4	189.0	1.8	-14.1	frz_fog
84	Apr-22-99	CLARIANT SAFEWING MP IV 1957	Neat	4	94.0	1.9	-14.2	frz_fog
85	Apr-22-99	OCTAGON MAXFLIGHT	75%	4b	71.0	2.1	-14.2	frz_fog
86	Apr-22-99	KILFROST ABC-S	75%	4b	58.0	2.0	-14.3	frz_fog
87	Apr-22-99	OCTAGON MAXFLIGHT	Neat	4	136.0	1.5	-14.3	frz_fog
88	Apr-22-99	KILFROST ABC-II PLUS	75%	2b	54.0	2.2	-13.8	frz_fog
89	Apr-22-99	CLARIANT SAFEWING MP IV 1957	75%	4b	74.0	1.8	-13.9	frz_fog
90	Apr-22-99	KILFROST ABC-S	75%	4b	61.0	2.1	-14.0	frz_fog
91	Apr-22-99	UCAR XL54	Std	1	14.8	1.8	-14.0	frz_fog
92	Apr-22-99	CLARIANT 1938	Std	1	12.0	1.7	-14.0	frz_fog

SIMULATED FREEZING FOG AT CEF FOR 1998-99

Test No.	Date	Fluid Name	Fluid Dilution	Fluid Type	Fail Time [min.]	Rate of precep. [g/dm*^{2}/hr]	Ambient Temp (°C)	Precip Type
93	Apr-22-99	INLAND DURAGLY-E	Std	1	14.3	1.6	-14.0	frz_fog
94	Apr-22-99	INLAND DURAGLY-E	Std	1	10.2	2.0	-14.0	frz_fog
95	Apr-22-99	INLAND DURAGLY-P	Std	1	13.2	1.7	-14.0	frz_fog
96	Apr-22-99	INLAND DURAGLY-P	Std	1	11.0	1.6	-14.0	frz_fog
97	Apr-23-99	KILFROST ABC-S	Neat	4	48.0	1.7	-25.7	frz_fog
98	Apr-23-99	FLUID X	Neat	4	135.0	2.1	-25.7	frz_fog
99	Apr-23-99	OCTAGON MAXFLIGHT	Neat	4	43.0	1.9	-25.7	frz_fog
100	Apr-23-99	CLARIANT SAFEWING MP IV 1957	Neat	4	43.0	1.8	-25.7	frz_fog
101	Apr-23-99	UCAR ULTRA+	Neat	4	141.0	1.8	-25.7	frz_fog
102	Apr-23-99	KILFROST ABC-S	Neat	4	46.0	1.7	-25.8	frz_fog
103	Apr-23-99	FLUID X	Neat	4	131.0	1.8	-25.7	frz_fog
104	Apr-23-99	UCAR ULTRA+	Neat	4	137.0	1.9	-25.7	frz_fog
105	Apr-23-99	OCTAGON MAXFLIGHT	Neat	4	40.0	1.7	-25.8	frz_fog
106	Apr-23-99	CLARIANT SAFEWING MP IV 1957	Neat	4	47.0	1.8	-25.5	frz_fog
107	Apr-23-99	KILFROST ABC-II PLUS	Neat	2	18.0	1.9	-25.5	frz_fog
108	Apr-23-99	KILFROST ABC-II PLUS	Neat	2	18.0	1.9	-25.5	frz_fog
109	Apr-23-99	INLAND DURAGLY-E	Std	1	8.3	1.9	-25.4	frz_fog
110	Apr-23-99	INLAND DURAGLY-P	Std	1	9.3	1.6	-25.4	frz_fog
111	Apr-23-99	INLAND DURAGLY-P	Std	1	9.4	1.7	-25.4	frz_fog
112	Apr-23-99	INLAND DURAGLY-E	Std	1	8.2	1.5	-25.4	frz_fog
113	Apr-23-99	CLARIANT 1938	Std	1	6.3	1.5	-25.6	frz_fog
114	Apr-23-99	UCAR ULTRA+	Neat	4	39.0	5.4	-25.0	frz_fog
115	Apr-23-99	FLUID X	Neat	4	46.0	5.4	-25.0	frz_fog
116	Apr-23-99	UCAR ULTRA+	Neat	4	38.0	5.4	-25.0	frz_fog
117	Apr-23-99	OCTAGON MAXFLIGHT	Neat	4	20.0	5.2	-24.9	frz_fog
118	Apr-23-99	FLUID X	Neat	4	44.0	4.9	-25.0	frz_fog
119	Apr-23-99	CLARIANT SAFEWING MP IV 1957	Neat	4	23.0	5.1	-24.9	frz_fog
120	Apr-23-99	KILFROST ABC-S	Neat	4	22.0	5.4	-24.9	frz_fog
121	Apr-23-99	KILFROST ABC-II PLUS	Neat	2	13.0	5.4	-24.9	frz_fog
122	Apr-23-99	KILFROST ABC-S	Neat	4	21.0	4.7	-25.0	frz_fog
123	Apr-23-99	INLAND DURAGLY-P	Std	1	4.8	5.5	-24.7	frz_fog
124	Apr-23-99	UCAR XL54	Std	1	5.8	5.7	-24.7	frz_fog
125	Apr-23-99	OCTAGON MAXFLIGHT	Neat	4	21.0	5.1	-24.8	frz_fog
126	Apr-23-99	KILFROST ABC-II PLUS	Neat	2	14.0	5.4	-24.8	frz_fog
127	Apr-23-99	CLARIANT SAFEWING MP IV 1957	Neat	4	22.0	5.4	-24.8	frz_fog
128	Apr-23-99	INLAND DURAGLY-E	Std	1	5.0	5.1	-24.9	frz_fog
129	Apr-23-99	INLAND DURAGLY-E	Std	1	5.5	4.7	-24.8	frz_fog
130	Apr-23-99	INLAND DURAGLY-P	Std	1	5.5	5.5	-24.8	frz_fog
131	Apr-23-99	CLARIANT 1938	Std	1	4.9	5.7	-24.8	frz_fog
132	Apr-26-99	FLUID X	Neat	4	100.0	5.4	-13.9	frz_fog
133	Apr-26-99	KILFROST ABC-S	Neat	4	41.0	5.4	-14.0	frz_fog
134	Apr-26-99	KILFROST ABC-II PLUS	Neat	2	29.0	5.4	-14.0	frz_fog
135	Apr-26-99	CLARIANT SAFEWING MP IV 1957	Neat	4	41.0	5.4	-14.0	frz_fog
136	Apr-26-99	UCAR ULTRA+	Neat	4	86.0	5.1	-13.9	frz_fog
137	Apr-26-99	UCAR ULTRA+	Neat	4	75.0	5.6	-13.9	frz_fog
138	Apr-26-99	FLUID X	Neat	4	102.0	6.0	-13.9	frz_fog

SIMULATED FREEZING FOG AT CEF FOR 1998-99

Test No.	Date	Fluid Name	Fluid Dilution	Fluid Type	Fail Time [min.]	Rate of precep. [g/dm*^{2}/hr]	Ambient Temp (°C)	Precip Type
139	Apr-26-99	KILFROST ABC-S	Neat	4	37.0	6.0	-14.0	frz_fog
140	Apr-26-99	OCTAGON MAXFLIGHT	Neat	4	40.0	5.8	-14.0	frz_fog
141	Apr-26-99	KILFROST ABC-II PLUS	Neat	2	28.0	5.7	-13.8	frz_fog
142	Apr-26-99	CLARIANT SAFEWING MP IV 1957	Neat	4	39.0	5.7	-13.8	frz_fog
143	Apr-26-99	OCTAGON MAXFLIGHT	75%	4b	27.0	5.6	-13.8	frz_fog
144	Apr-26-99	OCTAGON MAXFLIGHT	Neat	4	42.0	5.2	-13.8	frz_fog
145	Apr-26-99	OCTAGON MAXFLIGHT	75%	4b	26.0	5.4	-13.7	frz_fog
146	Apr-26-99	KILFROST ABC-S	75%	4b	24.0	5.9	-13.8	frz_fog
147	Apr-26-99	CLARIANT SAFEWING MP IV 1957	75%	4b	21.0	5.5	-13.8	frz_fog
148	Apr-26-99	INLAND DURAGLY-E	Std	1	6.8	5.3	-13.6	frz_fog
149	Apr-26-99	KILFROST ABC-II PLUS	75%	2b	19.0	5.7	-13.6	frz_fog
150	Apr-26-99	INLAND DURAGLY-P	Std	1	7.0	5.7	-13.6	frz_fog
151	Apr-26-99	INLAND DURAGLY-E	Std	1	6.7	5.6	-13.6	frz_fog
152	Apr-26-99	KILFROST ABC-S	75%	4b	23.0	5.3	-13.6	frz_fog
153	Apr-26-99	INLAND DURAGLY-P	Std	1	6.5	6.0	-13.6	frz_fog
154	Apr-26-99	KILFROST ABC-II PLUS	75%	2b	20.0	5.7	-13.6	frz_fog
155	Apr-26-99	CLARIANT SAFEWING MP IV 1957	75%	4b	20.0	5.5	-13.6	frz_fog
156	Apr-26-99	CLARIANT 1938	Std	1	6.9	5.3	-13.6	frz_fog
157	Apr-26-99	UCAR XL54	Std	1	8.2	5.6	-13.6	frz_fog

COLDSOAK BOXES AT CEF FOR 1998-99

Test No.	Date	Fluid Name	Fluid Dilution	Fluid Type	Fail Time [min.]	Rate of precep. [g/dm*²/hr]	Ambient Temp [C]	Precip Type
1	Apr-20-99	UCAR ULTRA+	Neat	4	89.0	4.6	1.1	drizzle
2	Apr-20-99	OCTAGON MAXFLIGHT	Neat	4	133.0	4.8	1.1	drizzle
3	Apr-20-99	FLUID X	Neat	4	190.0	5.4	0.8	drizzle
4	Apr-20-99	KILFROST ABC-S	Neat	4	195.0	5.6	1.3	drizzle
5	Apr-20-99	UCAR ULTRA+	Neat	4	83.0	4.6	1.2	drizzle
6	Apr-20-99	KILFROST ABC-II PLUS	Neat	2	56.0	4.7	1.1	drizzle
7	Apr-20-99	OCTAGON MAXFLIGHT	75%	4b	77.0	5.1	1.0	drizzle
8	Apr-20-99	CLARIANT SAFEWING MP IV 1957	Neat	4	71.0	5.4	0.9	drizzle
9	Apr-20-99	KILFROST ABC-II PLUS	Neat	2	60.0	5.7	0.9	drizzle
10	Apr-20-99	KILFROST ABC-S	75%	4b	83.0	4.7	0.8	drizzle
11	Apr-20-99	CLARIANT SAFEWING MP IV 1957	75%	4b	66.0	4.9	1.0	drizzle
12	Apr-20-99	CLARIANT SAFEWING MP IV 1957	Neat	4	67.0	5.1	0.3	drizzle
13	Apr-20-99	KILFROST ABC-II PLUS	75%	2b	41.0	6.0	1.2	drizzle
14	Apr-20-99	UCAR XL54	Std	1	10.0	4.8	0.9	drizzle
15	Apr-20-99	INLAND DURAGLY-E	Std	1	7.4	5.0	1.2	drizzle
16	Apr-20-99	INLAND DURAGLY-P	Std	1	9.0	5.4	1.1	drizzle
17	Apr-20-99	KILFROST ABC-II PLUS	75%	2b	47.0	5.8	0.9	drizzle
18	Apr-20-99	INLAND DURAGLY-P	Std	1	8.3	4.7	0.9	drizzle
19	Apr-20-99	CLARIANT 1938	Std	1	7.5	4.8	0.9	drizzle
20	Apr-20-99	INLAND DURAGLY-E	Std	1	8.4	5.3	1.2	drizzle
21	Apr-21-99	KILFROST ABC-S	Neat	4	31.0	67.5	1.2	mod_rain
22	Apr-21-99	OCTAGON MAXFLIGHT	Neat	4	12.0	68.5	1.0	mod_rain
23	Apr-21-99	KILFROST ABC-S	Neat	4	39.0	70.7	1.1	mod_rain
24	Apr-21-99	CLARIANT SAFEWING MP IV 1957	Neat	4	16.0	67.5	0.8	mod_rain
25	Apr-26-99	FLUID X	Neat	4	181.0	4.7	1.0	drizzle
26	Apr-26-99	KILFROST ABC-S	75%	4b	76.0	4.9	1.1	drizzle
27	Apr-26-99	CLARIANT SAFEWING MP IV 1957	75%	4b	64.0	5.5	0.8	drizzle
28	Apr-26-99	OCTAGON MAXFLIGHT	Neat	4	153.0	5.1	0.8	drizzle
29	Apr-26-99	OCTAGON MAXFLIGHT	75%	4b	77.0	5.0	0.9	drizzle
30	Apr-26-99	CLARIANT SAFEWING MP IV 1957	75%	4b	56.0	5.3	0.8	drizzle
31	Apr-27-99	CLARIANT SAFEWING MP IV 1957	Neat	4	13.0	64.9	1.0	mod_rain
32	Apr-27-99	UCAR ULTRA+	Neat	4	12.0	69.3	1.0	mod_rain
33	Apr-27-99	FLUID X	Neat	4	16.0	70.2	0.9	mod_rain
34	Apr-27-99	OCTAGON MAXFLIGHT	75%	4b	8.0	72.3	0.8	mod_rain
35	Apr-27-99	CLARIANT SAFEWING MP IV 1957	Neat	4	12.0	74.0	1.0	mod_rain
36	Apr-27-99	KILFROST ABC-S	Neat	4	30.0	73.6	1.0	mod_rain
37	Apr-27-99	KILFROST ABC-II PLUS	Neat	2	7.0	70.0	1.2	mod_rain
38	Apr-27-99	OCTAGON MAXFLIGHT	Neat	4	14.0	70.2	1.1	mod_rain
39	Apr-27-99	UCAR ULTRA+	Neat	4	13.0	72.5	0.9	mod_rain
40	Apr-27-99	FLUID X	Neat	4	18.0	73.9	1.2	mod_rain
41	Apr-27-99	KILFROST ABC-II PLUS	Neat	2	7.0	69.0	0.9	mod_rain
42	Apr-27-99	CLARIANT SAFEWING MP IV 1957	75%	4b	10.0	75.0	0.9	mod_rain
43	Apr-27-99	OCTAGON MAXFLIGHT	75%	4b	9.0	73.7	1.3	mod_rain
44	Apr-27-99	CLARIANT SAFEWING MP IV 1957	75%	4b	10.0	71.6	0.9	mod_rain
45	Apr-27-99	KILFROST ABC-II PLUS	75%	2b	7.0	70.3	1.1	mod_rain

COLDSOAK BOXES AT CEF FOR 1998-99

Test No.	Date	Fluid Name	Fluid Dilution	Fluid Type	Fail Time [min.]	Rate of precep. [g/dm*²/hr]	Ambient Temp [C]	Precip Type
46	Apr-27-99	KILFROST ABC-S	75%	4b	12.0	70.6	0.9	mod_rain
47	Apr-27-99	KILFROST ABC-II PLUS	75%	2b	7.0	74.0	1.2	mod_rain
48	Apr-27-99	KILFROST ABC-S	75%	4b	12.0	76.0	1.2	mod_rain
49	Apr-27-99	INLAND DURAGLY-P	Std	1	2.1	68.0	0.9	mod_rain
50	Apr-27-99	INLAND DURAGLY-E	Std	1	1.8	75.6	0.8	mod_rain
51	Apr-27-99	CLARIANT 1938	Std	1	1.8	69.7	1.2	mod_rain
52	Apr-27-99	KILFROST ABC-S	Neat	4	29.0	69.8	0.9	mod_rain
53	Apr-27-99	UCAR XL54	Std	1	2.0	74.3	1.1	mod_rain
54	Apr-27-99	OCTAGON MAXFLIGHT	Neat	4	13.0	75.7	1.0	mod_rain

TYPE I HOLDOVER TIME TEST - SIMULATED FREEZING PRECIPITATION AT CEF FOR 1998-99

Test No.	Date	Fluid Name	Fluid Dilution	Fluid Type	fail time [min.]	Rate of precep. [g/dm**2/hr]	Ambient Temp [C]	Precip Type
1	Jul-16-99	JAR KLEER	-20	1a	8.7	4.7	-10.0	frz_drizzle
2	Jul-16-99	UCAR ADF	-20	1a	8.6	4.9	-10.0	frz_drizzle
3	Jul-16-99	OCTAFLO	-20	1a	8.2	5.6	-10.0	frz_drizzle
4	Jul-16-99	CLARIANT SAFEWING EG I 1996	-20	1a	7.4	4.9	-10.0	frz_drizzle
5	Jul-16-99	HOMEOIL SAFETEMP	-20	1a	8.5	5.2	-10.0	frz_drizzle
6	Jul-16-99	UCAR ADF	-20	1a	8.3	4.7	-10.0	frz_drizzle
7	Jul-16-99	CLARIANT SAFEWING EG I 1996	-20	1a	8.2	4.9	-10.0	frz_drizzle
8	Jul-16-99	OCTAFLO	-20	1a	7.8	5.4	-10.0	frz_drizzle
9	Jul-16-99	OCTAFLO EF	-20	1a	8.2	4.9	-10.0	frz_drizzle
10	Jul-16-99	KILFROST DF PLUS	-20	1a	8.4	5.2	-10.0	frz_drizzle
11	Jul-16-99	OCTAFLO EF	-20	1a	8.6	4.7	-10.0	frz_drizzle
12	Jul-16-99	KILFROST DF PLUS	-20	1a	9.3	5.0	-10.0	frz_drizzle
13	Jul-16-99	INLAND DURAGLY-P	-20	1a	8.0	5.3	-10.0	frz_drizzle
14	Jul-16-99	INLAND DURAGLY-P	-20	1a	8.7	4.6	-10.0	frz_drizzle
15	Jul-16-99	HOMEOIL SAFETEMP	-20	1a	8.7	4.7	-10.0	frz_drizzle
16	Jul-16-99	JAR KLEER	-20	1a	8.2	5.0	-10.0	frz_drizzle
17	Jul-16-99	WATER	0		6.3	5.4	-10.0	frz_drizzle
18	Jul-16-99	UCAR ADF	-20	1a	6.0	12.0	-10.0	frz_drizzle
19	Jul-16-99	CLARIANT SAFEWING EG I 1996	-20	1a	5.8	12.6	-10.0	frz_drizzle
20	Jul-16-99	OCTAFLO	-20	1a	5.7	12.8	-10.0	frz_drizzle
21	Jul-16-99	OCTAFLO EF	-20	1a	5.2	12.8	-10.0	frz_drizzle
22	Jul-16-99	KILFROST DF PLUS	-20	1a	5.7	12.2	-10.0	frz_drizzle
23	Jul-16-99	INLAND DURAGLY-P	-20	1a	5.5	12.7	-10.0	frz_drizzle
24	Jul-16-99	HOMEOIL SAFETEMP	-20	1a	5.0	13.4	-10.0	frz_drizzle
25	Jul-16-99	JAR KLEER	-20	1a	5.8	12.0	-10.0	frz_drizzle
26	Jul-16-99	UCAR ADF	-20	1a	5.7	12.6	-10.0	frz_drizzle
27	Jul-16-99	CLARIANT SAFEWING EG I 1996	-20	1a	5.3	12.8	-10.0	frz_drizzle
28	Jul-16-99	OCTAFLO	-20	1a	5.4	12.8	-10.0	frz_drizzle
29	Jul-16-99	OCTAFLO EF	-20	1a	5.6	12.2	-10.0	frz_drizzle
30	Jul-16-99	KILFROST DF PLUS	-20	1a	5.4	12.7	-10.0	frz_drizzle
31	Jul-16-99	INLAND DURAGLY-P	-20	1a	5.3	13.4	-10.0	frz_drizzle
32	Jul-16-99	JAR KLEER	-20	1a	6.3	12.6	-10.0	frz_drizzle
33	Jul-16-99	HOMEOIL SAFETEMP	-20	1a	5.8	12.8	-10.0	frz_drizzle
34	Jul-16-99	WATER	0		4.5	12.8	-10.0	frz_drizzle
35	Jul-19-99	KILFROST DF PLUS	LOUT	1a	12.4	2.1	-30.7	frz_fog
36	Jul-19-99	INLAND DURAGLY-P	LOUT	1a	11.7	2.1	-30.7	frz_fog
37	Jul-19-99	KILFROST DF PLUS	LOUT	1a	11.9	2.1	-30.8	frz_fog
38	Jul-19-99	INLAND DURAGLY-P	LOUT	1a	10.7	1.7	-30.8	frz_fog
39	Jul-19-99	HOMEOIL SAFETEMP	-40	1a	13.2	1.8	-31.0	frz_fog
40	Jul-19-99	OCTAFLO EF	-40	1a	14.3	2.1	-31.0	frz_fog
41	Jul-19-99	OCTAFLO	-40	1a	14.2	2.1	-31.0	frz_fog
42	Jul-19-99	HOMEOIL SAFETEMP	-40	1a	14.6	2.1	-31.0	frz_fog
43	Jul-19-99	JAR KLEER	-40	1a	19.6	1.7	-31.1	frz_fog
44	Jul-19-99	UCAR ADF	-40	1a	11.2	1.6	-31.0	frz_fog
45	Jul-19-99	JAR KLEER	-40	1a	19.8	1.7	-31.2	frz_fog
46	Jul-19-99	OCTAFLO	-40	1a	17.2	1.6	-31.2	frz_fog
47	Jul-19-99	OCTAFLO EF	-40	1a	13.7	1.5	-31.2	frz_fog
48	Jul-19-99	UCAR ADF	-40	1a	15.3	1.5	-31.2	frz_fog
49	Jul-20-99	CLARIANT SAFEWING EG I 1996	-40	1a	11.0	2.6	-30.8	frz_fog
50	Jul-20-99	CLARIANT SAFEWING EG I 1996	-40	1a	9.8	2.8	-30.8	frz_fog
51	Jul-20-99	UCAR ADF	-40	1a	6.0	5.1	-30.5	frz_fog
52	Jul-20-99	JAR KLEER	-40	1a	7.3	5.5	-30.5	frz_fog
53	Jul-20-99	HOMEOIL SAFETEMP	-40	1a	6.6	5.3	-30.5	frz_fog

TYPE I HOLDOVER TIME TEST - SIMULATED FREEZING PRECIPITATION AT CEF FOR 1998-99

Test No.	Date	Fluid Name	Fluid Dilution	Fluid Type	fail time [min.]	Rate of precep. [g/dm*²/hr]	Ambient Temp [C]	Precip Type
54	Jul-20-99	OCTAFLO	-40	1a	8.5	4.9	-30.5	frz_fog
55	Jul-20-99	OCTAFLO EF	-40	1a	8.2	5.2	-30.5	frz_fog
56	Jul-20-99	CLARIANT SAFEWING EG I 1996	-40	1a	5.7	5.3	-30.5	frz_fog
57	Jul-20-99	INLAND DURAGLY-P	-40	1a	8.5	5.1	-30.5	frz_fog
58	Jul-20-99	KILFROST DF PLUS	-40	1a	8.7	4.8	-30.5	frz_fog
59	Jul-20-99	HOMEOIL SAFETEMP	-40	1a	7.5	5.1	-30.4	frz_fog
60	Jul-20-99	UCAR ADF	-40	1a	5.3	5.5	-30.5	frz_fog
61	Jul-20-99	JAR KLEER	-40	1a	8.0	5.3	-30.4	frz_fog
62	Jul-20-99	KILFROST DF PLUS	-40	1a	9.0	4.9	-30.3	frz_fog
63	Jul-20-99	INLAND DURAGLY-P	-40	1a	8.2	5.2	-30.3	frz_fog
64	Jul-20-99	OCTAFLO	-40	1a	8.6	5.3	-30.3	frz_fog
65	Jul-20-99	OCTAFLO EF	-40	1a	8.3	5.1	-30.3	frz_fog
66	Jul-20-99	CLARIANT SAFEWING EG I 1996	-40	1a	6.5	4.8	-30.2	frz_fog
67	Jul-20-99	UCAR ADF	-20	1a	6.7	4.8	-10.6	frz_fog
68	Jul-20-99	HOMEOIL SAFETEMP	-20	1a	6.8	4.9	-10.6	frz_fog
69	Jul-20-99	JAR KLEER	-20	1a	6.3	5.0	-10.6	frz_fog
70	Jul-20-99	OCTAFLO	-20	1a	7.4	5.5	-10.6	frz_fog
71	Jul-20-99	OCTAFLO EF	-20	1a	6.8	5.8	-10.6	frz_fog
72	Jul-20-99	KILFROST DF PLUS	-20	1a	7.5	4.4	-10.5	frz_fog
73	Jul-20-99	INLAND DURAGLY-P	-20	1a	6.8	4.5	-10.6	frz_fog
74	Jul-20-99	WATER			1.5	4.8	-10.6	frz_fog
75	Jul-20-99	UCAR ADF	-20	1a	5.8	5.3	-10.6	frz_fog
76	Jul-20-99	INLAND DURAGLY-P	-20	1a	7.3	4.8	-10.5	frz_fog
77	Jul-20-99	CLARIANT SAFEWING EG I 1996	-20	1a	6.7	4.9	-10.5	frz_fog
78	Jul-20-99	HOMEOIL SAFETEMP	-20	1a	7.0	5.0	-10.5	frz_fog
79	Jul-20-99	JAR KLEER	-20	1a	7.0	5.5	-10.5	frz_fog
80	Jul-20-99	OCTAFLO	-20	1a	7.1	5.8	-10.5	frz_fog
81	Jul-20-99	OCTAFLO EF	-20	1a	7.3	4.5	-10.4	frz_fog
82	Jul-20-99	CLARIANT SAFEWING EG I 1996	-20	1a	6.8	4.8	-10.4	frz_fog
83	Jul-20-99	KILFROST DF PLUS	-20	1a	7.1	5.3	-10.4	frz_fog
84	Jul-20-99	WATER			3.1	1.6	-10.6	frz_fog
85	Jul-20-99	INLAND DURAGLY-P	-20	1a	12.4	1.7	-10.5	frz_fog
86	Jul-20-99	CLARIANT SAFEWING EG I 1996	-20	1a	11.8	1.7	-10.5	frz_fog
87	Jul-20-99	JAR KLEER	-20	1a	11.8	1.7	-10.5	frz_fog
88	Jul-20-99	HOMEOIL SAFETEMP	-20	1a	10.8	1.9	-10.5	frz_fog
89	Jul-20-99	OCTAFLO EF	-20	1a	12.8	1.5	-10.5	frz_fog
90	Jul-20-99	KILFROST DF PLUS	-20	1a	13.8	1.5	-10.5	frz_fog
91	Jul-20-99	OCTAFLO	-20	1a	13.3	1.4	-10.5	frz_fog
92	Jul-20-99	UCAR ADF	-20	1a	11.5	1.7	-10.5	frz_fog
93	Jul-20-99	INLAND DURAGLY-P	-20	1a	12.3	1.6	-10.5	frz_fog
94	Jul-20-99	UCAR ADF	-20	1a	11.8	1.7	-10.5	frz_fog
95	Jul-20-99	OCTAFLO EF	-20	1a	13.3	1.7	-10.5	frz_fog
96	Jul-20-99	KILFROST DF PLUS	-20	1a	13.5	1.7	-10.5	frz_fog
97	Jul-20-99	OCTAFLO	-20	1a	12.8	1.9	-10.5	frz_fog
98	Jul-20-99	HOMEOIL SAFETEMP	-20	1a	14.2	1.6	-10.5	frz_fog
99	Jul-20-99	JAR KLEER	-20	1a	12.7	1.5	-10.5	frz_fog
100	Jul-20-99	CLARIANT SAFEWING EG I 1996	-20	1a	11.5	1.4	-10.5	frz_fog
101	Jul-21-99	HOMEOIL SAFETEMP	-20	1a	5.9	12.4	-9.7	frz_rain
102	Jul-21-99	OCTAFLO	-20	1a	5.3	12.0	-9.7	frz_rain
103	Jul-21-99	WATER			14.7	12.5	-9.6	frz_rain
104	Jul-21-99	KILFROST DF PLUS	-20	1a	5.4	13.3	-9.7	frz_rain
105	Jul-21-99	INLAND DURAGLY-P	-20	1a	4.8	13.1	-9.7	frz_rain
106	Jul-21-99	UCAR ADF	-20	1a	5.2	12.5	-9.6	frz_rain

TYPE I HOLDOVER TIME TEST - SIMULATED FREEZING PRECIPITATION AT CEF FOR 1998-99

Test No.	Date	Fluid Name	Fluid Dilution	Fluid Type	fail time [min.]	Rate of precep. [g/dm*²/hr]	Ambient Temp [C]	Precip Type
107	Jul-21-99	JAR KLEER	-20	1a	5.7	12.4	-9.6	frz_rain
108	Jul-21-99	OCTAFLO EF	-20	1a	5.8	12.4	-9.6	frz_rain
109	Jul-21-99	CLARIANT SAFEWING EG I 1996	-20	1a	5.2	13.5	-9.7	frz_rain
110	Jul-21-99	UCAR ADF	-20	1a	4.8	12.4	-10.0	frz_rain
111	Jul-21-99	OCTAFLO	-20	1a	5.2	12.0	-10.0	frz_rain
112	Jul-21-99	OCTAFLO EF	-20	1a	5.3	13.3	-10.0	frz_rain
113	Jul-21-99	JAR KLEER	-20	1a	5.2	13.1	-10.0	frz_rain
114	Jul-21-99	CLARIANT SAFEWING EG I 1996	-20	1a	5.5	12.5	-10.0	frz_rain
115	Jul-21-99	INLAND DURAGLY-P	-20	1a	5.3	12.4	-10.0	frz_rain
116	Jul-21-99	KILFROST DF PLUS	-20	1a	5.0	12.4	-10.0	frz_rain
117	Jul-21-99	HOMEOIL SAFETEMP	-20	1a	5.3	13.5	-10.0	frz_rain
118	Jul-21-99	HOMEOIL SAFETEMP	-20	1a	4.0	25.7	-10.1	frz_rain
119	Jul-21-99	UCAR ADF	-20	1a	4.1	24.8	-10.1	frz_rain
120	Jul-21-99	JAR KLEER	-20	1a	4.4	25.1	-10.1	frz_rain
121	Jul-21-99	INLAND DURAGLY-P	-20	1a	4.4	25.8	-10.1	frz_rain
122	Jul-21-99	OCTAFLO	-20	1a	4.0	26.3	-10.1	frz_rain
123	Jul-21-99	KILFROST DF PLUS	-20	1a	4.3	26.3	-10.1	frz_rain
124	Jul-21-99	OCTAFLO EF	-20	1a	4.3	25.7	-10.1	frz_rain
125	Jul-21-99	CLARIANT SAFEWING EG I 1996	-20	1a	4.0	24.8	-10.1	frz_rain
126	Jul-21-99	UCAR ADF	-20	1a	4.0	25.1	-10.1	frz_rain
127	Jul-21-99	WATER	-20		3.5	25.8	-10.1	frz_rain
128	Jul-21-99	OCTAFLO	-20	1a	4.2	26.3	-10.1	frz_rain
129	Jul-21-99	INLAND DURAGLY-P	-20	1a	4.1	26.3	-10.1	frz_rain
130	Jul-21-99	JAR KLEER	-20	1a	4.2	25.7	-10.1	frz_rain
131	Jul-21-99	CLARIANT SAFEWING EG I 1996	-20	1a	3.9	24.8	-10.1	frz_rain
132	Jul-21-99	OCTAFLO EF	-20	1a	4.1	25.1	-10.1	frz_rain
133	Jul-21-99	KILFROST DF PLUS	-20	1a	4.3	25.8	-10.1	frz_rain
134	Jul-21-99	HOMEOIL SAFETEMP	-20	1a	4.1	26.3	-10.1	frz_rain
135	Jul-22-99	OCTAFLO EF	-9	1a	6.2	4.9	1.2	drizzle
136	Jul-22-99	OCTAFLO	-9	1a	6.2	4.9	1.7	drizzle
137	Jul-22-99	JAR KLEER	-9	1a	6.3	5.4	1.5	drizzle
138	Jul-22-99	HOMEOIL SAFETEMP	-9	1a	6.5	5.1	1.6	drizzle
139	Jul-22-99	UCAR ADF	-9	1a	6.3	5.4	1.5	drizzle
140	Jul-22-99	CLARIANT SAFEWING EG I 1996	-9	1a	5.0	4.9	1.6	drizzle
141	Jul-22-99	KILFROST DF PLUS	-9	1a	6.8	4.9	1.5	drizzle
142	Jul-22-99	INLAND DURAGLY-P	-9	1a	7.1	5.4	1.6	drizzle
143	Jul-22-99	CLARIANT SAFEWING EG I 1996	-9	1a	5.2	5.3	1.6	drizzle
144	Jul-22-99	INLAND DURAGLY-P	-9	1a	6.1	5.4	1.5	drizzle
145	Jul-22-99	KILFROST DF PLUS	-9	1a	6.3	5.2	1.6	drizzle
146	Jul-22-99	OCTAFLO EF	-9	1a	6.1	4.4	1.5	drizzle
147	Jul-22-99	OCTAFLO	-9	1a	6.3	4.8	1.5	drizzle
148	Jul-22-99	UCAR ADF	-9	1a	6.0	5.4	1.5	drizzle
149	Jul-22-99	JAR KLEER	-9	1a	6.4	4.8	1.5	drizzle
150	Jul-22-99	HOMEOIL SAFETEMP	-9	1a	6.2	5.2	1.5	drizzle
151	Jul-22-99	UCAR ADF	-9	1a	2.0	65.9	1.2	mod_rain
152	Jul-22-99	JAR KLEER	-9	1a	1.8	69.4	1.2	mod_rain
153	Jul-22-99	OCTAFLO EF	-9	1a	1.8	65.7	1.4	mod_rain
154	Jul-22-99	HOMEOIL SAFETEMP	-9	1a	1.9	67.8	1.2	mod_rain
155	Jul-22-99	INLAND DURAGLY-P	-9	1a	2.1	64.4	1.6	mod_rain
156	Jul-22-99	OCTAFLO	-9	1a	1.9	65.9	1.7	mod_rain
157	Jul-22-99	CLARIANT SAFEWING EG I 1996	-9	1a	1.7	69.4	1.5	mod_rain
158	Jul-22-99	KILFROST DF PLUS	-9	1a	1.8	65.7	1.7	mod_rain
159	Jul-22-99	CLARIANT SAFEWING EG I 1996	-9	1a	1.8	67.7	1.4	mod_rain

TYPE I HOLDOVER TIME TEST - SIMULATED FREEZING PRECIPITATION AT CEF FOR 1998-99

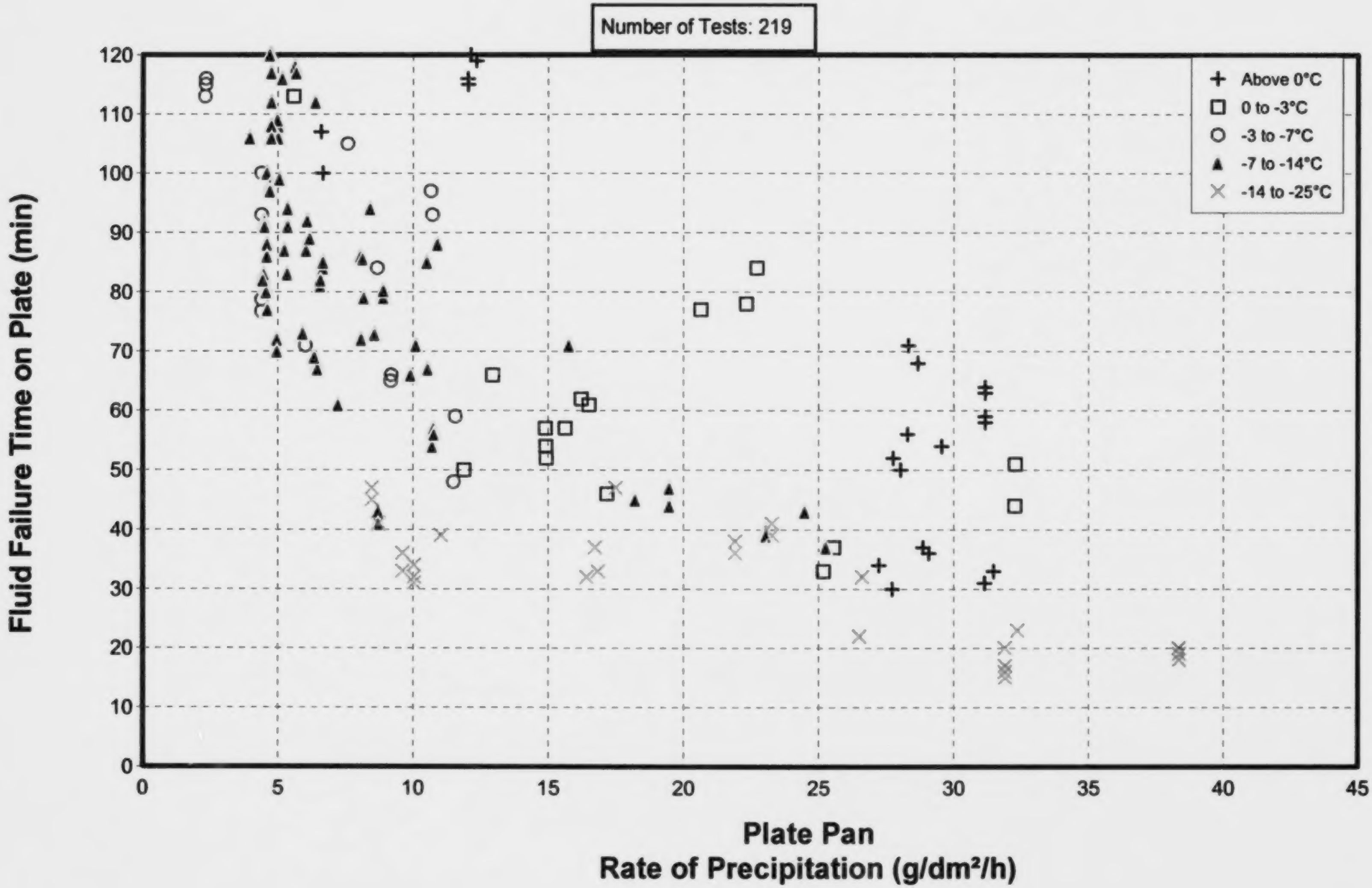
Test No.	Date	Fluid Name	Fluid Dilution	Fluid Type	fail time [min.]	Rate of precep. [g/dm*²/hr]	Ambient Temp [C]	Precip Type
160	Jul-22-99	UCAR ADF	-9	1a	1.8	63.8	1.4	mod_rain
161	Jul-22-99	KILFROST DF PLUS	-9	1a	1.9	65.4	1.5	mod_rain
162	Jul-22-99	HOMEOIL SAFETEMP	-9	1a	2.0	63.4	1.5	mod_rain
163	Jul-22-99	OCTAFLO EF	-9	1a	2.1	63.2	1.5	mod_rain
164	Jul-22-99	JAR KLEER	-9	1a	1.8	67.4	1.7	mod_rain
165	Jul-22-99	INLAND DURAGLY-P	-9	1a	2.0	63.8	1.6	mod_rain
166	Jul-22-99	OCTAFLO	-9	1a	2.1	65.4	1.7	mod_rain

APPENDIX F

EVALUATION OF TEST DATA USING REGRESSION METHOD

EFFECT OF TEMPERATURE AND RATE OF PRECIPITATION ON ENDURANCE TIME

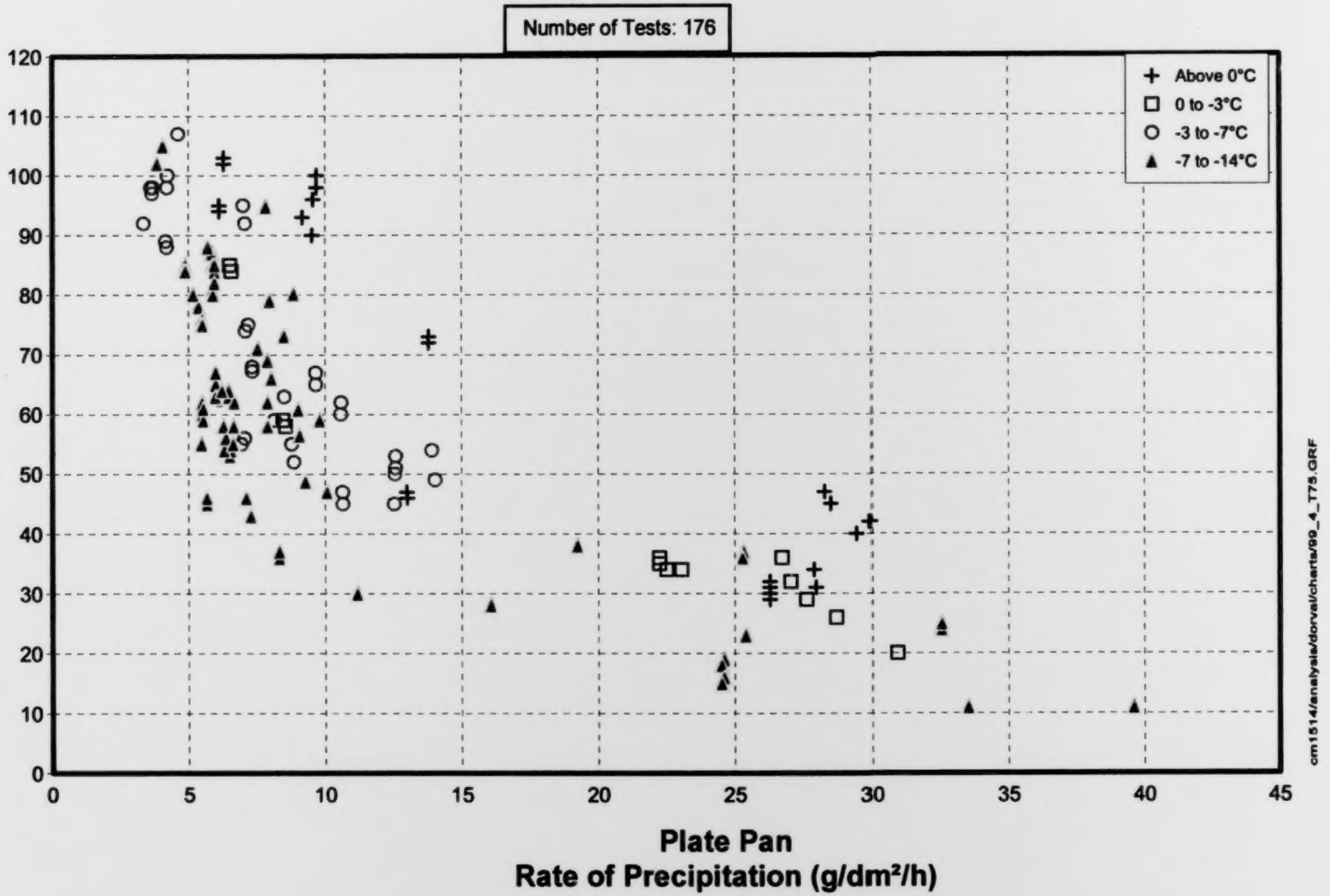
TYPE IV NEAT
NATURAL SNOW CONDITIONS
1998-99



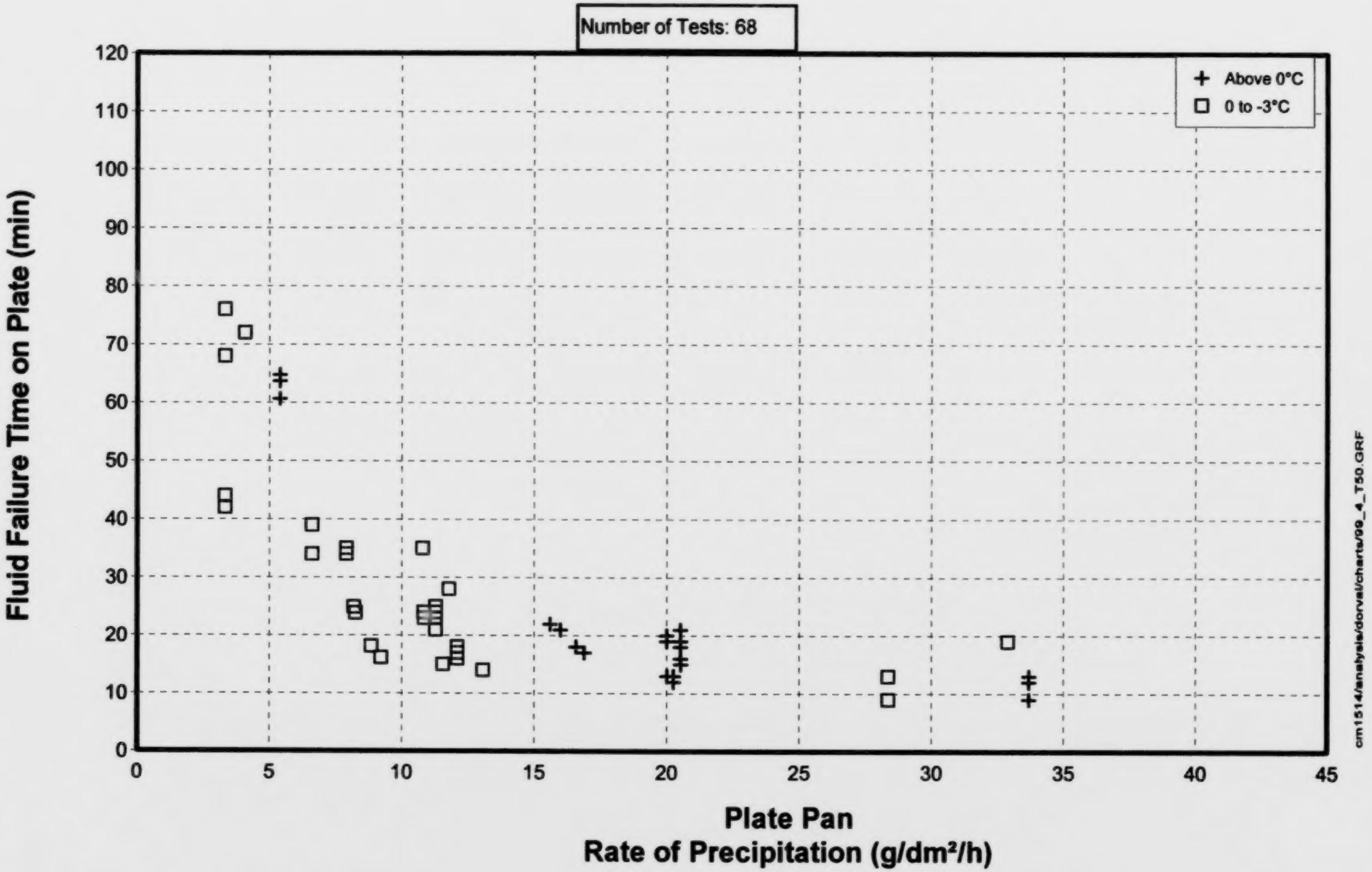
cm1514/analysis/dorval/charts/99_4_T4.GRF

EFFECT OF TEMPERATURE AND RATE OF PRECIPITATION ON ENDURANCE TIME

TYPE IV 75/25
NATURAL SNOW CONDITIONS
1998-99



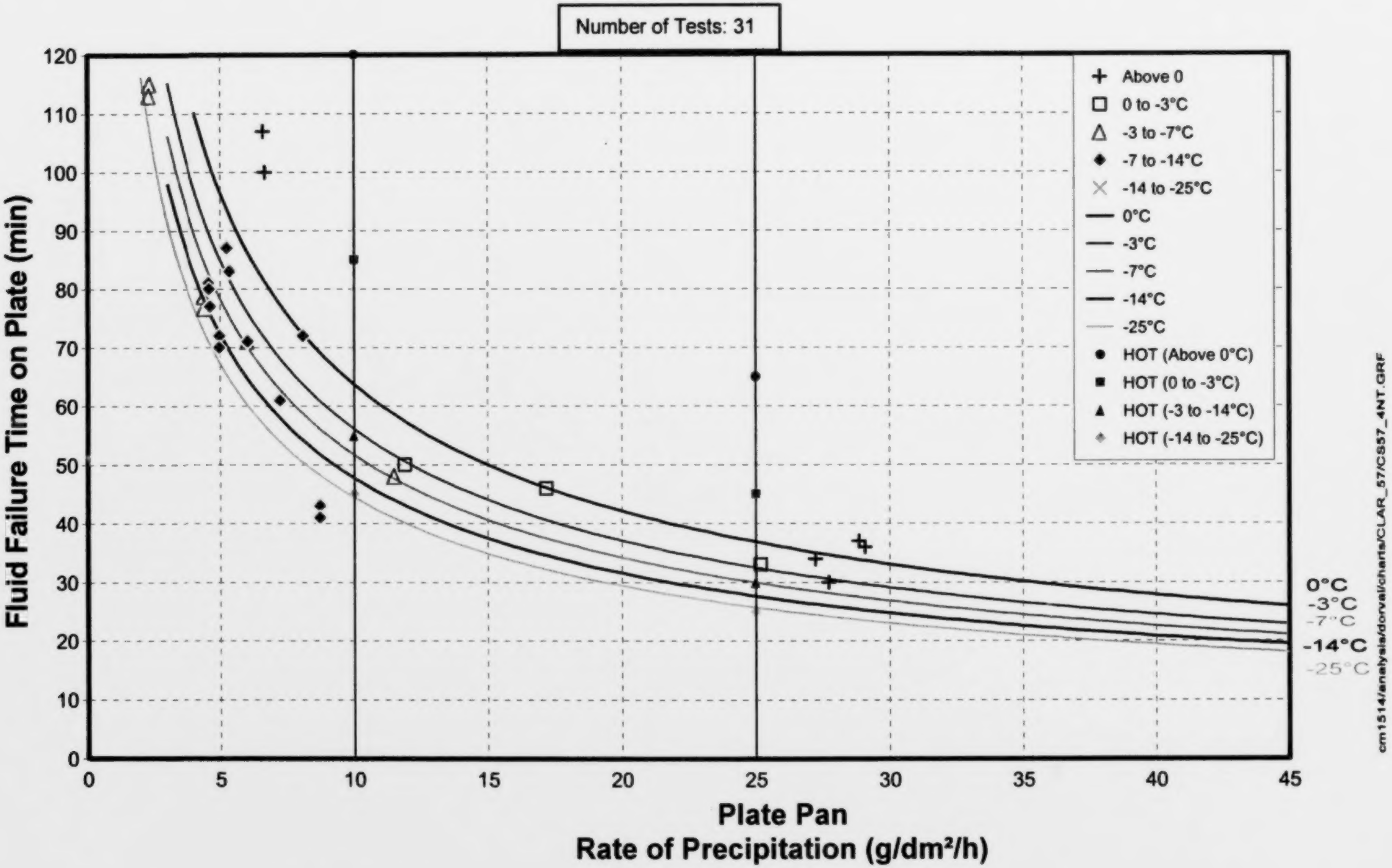
TYPE IV 50/50
NATURAL SNOW CONDITIONS
1998-99



CLARIANT SAFEWING MPIV 1957 TYPE IV NEAT

NATURAL SNOW CONDITIONS

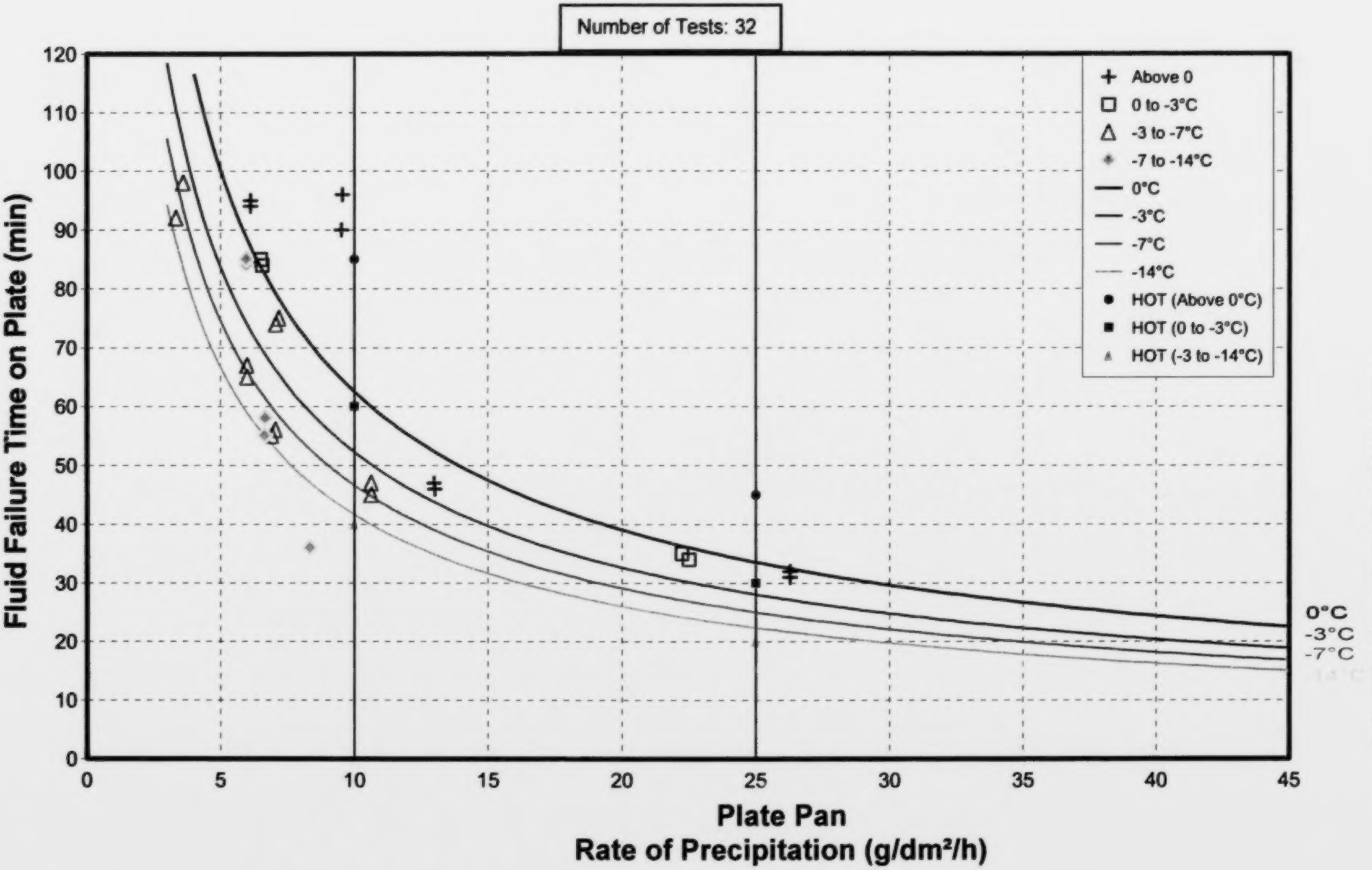
1998-99



CLARIANT SAFEWING MPIV 1957 TYPE IV 75/25

NATURAL SNOW CONDITIONS

1998-99

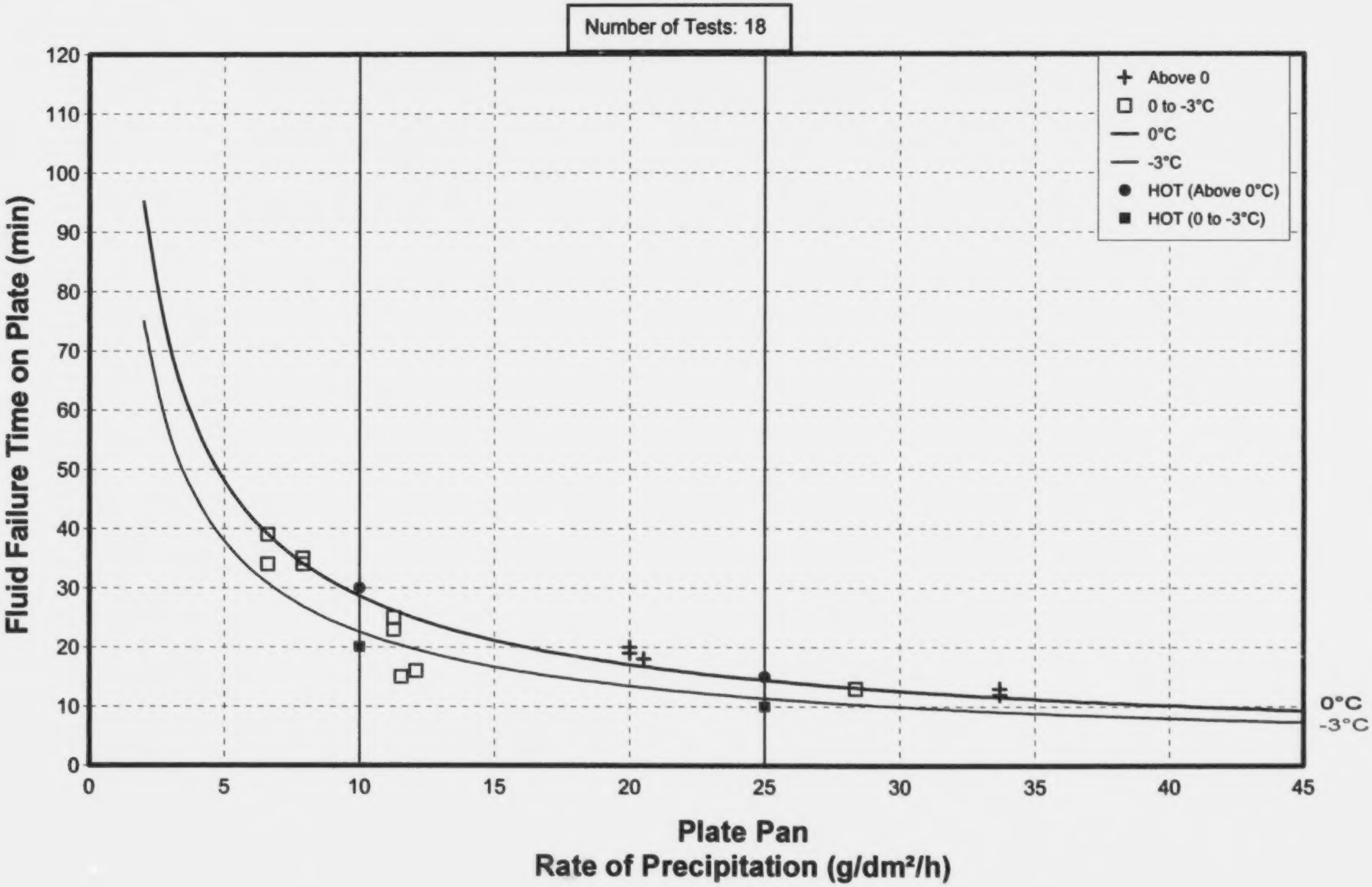


cm1514/analysis/dorval/charts/CLAR_57/CS57_47.GRF

CLARIANT SAFEWING MPIV 1957 TYPE IV 50/50

NATURAL SNOW CONDITIONS

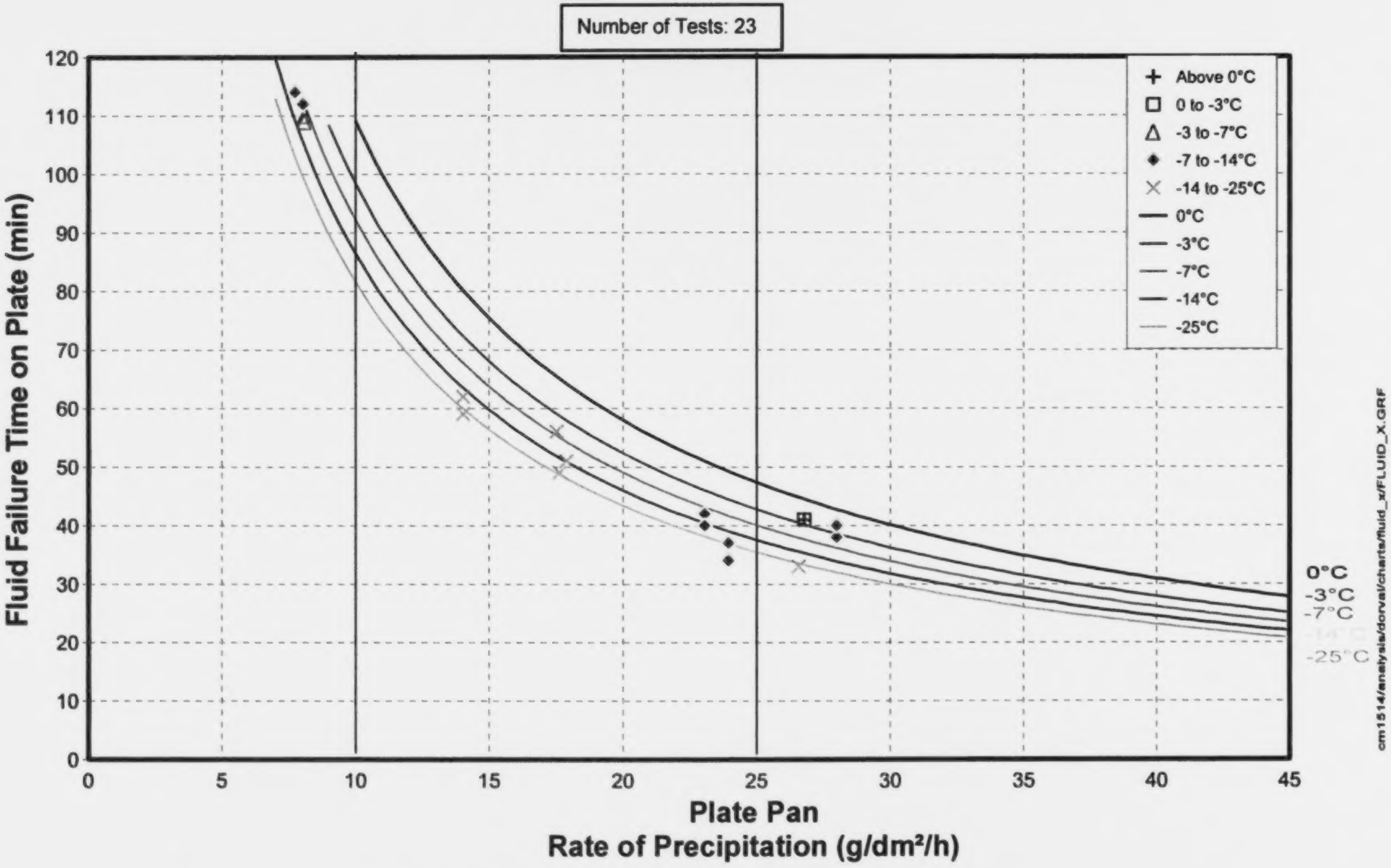
1998-99



cm1514/analysis/dorval/charts/CLAR_57/CS57_45.GRF

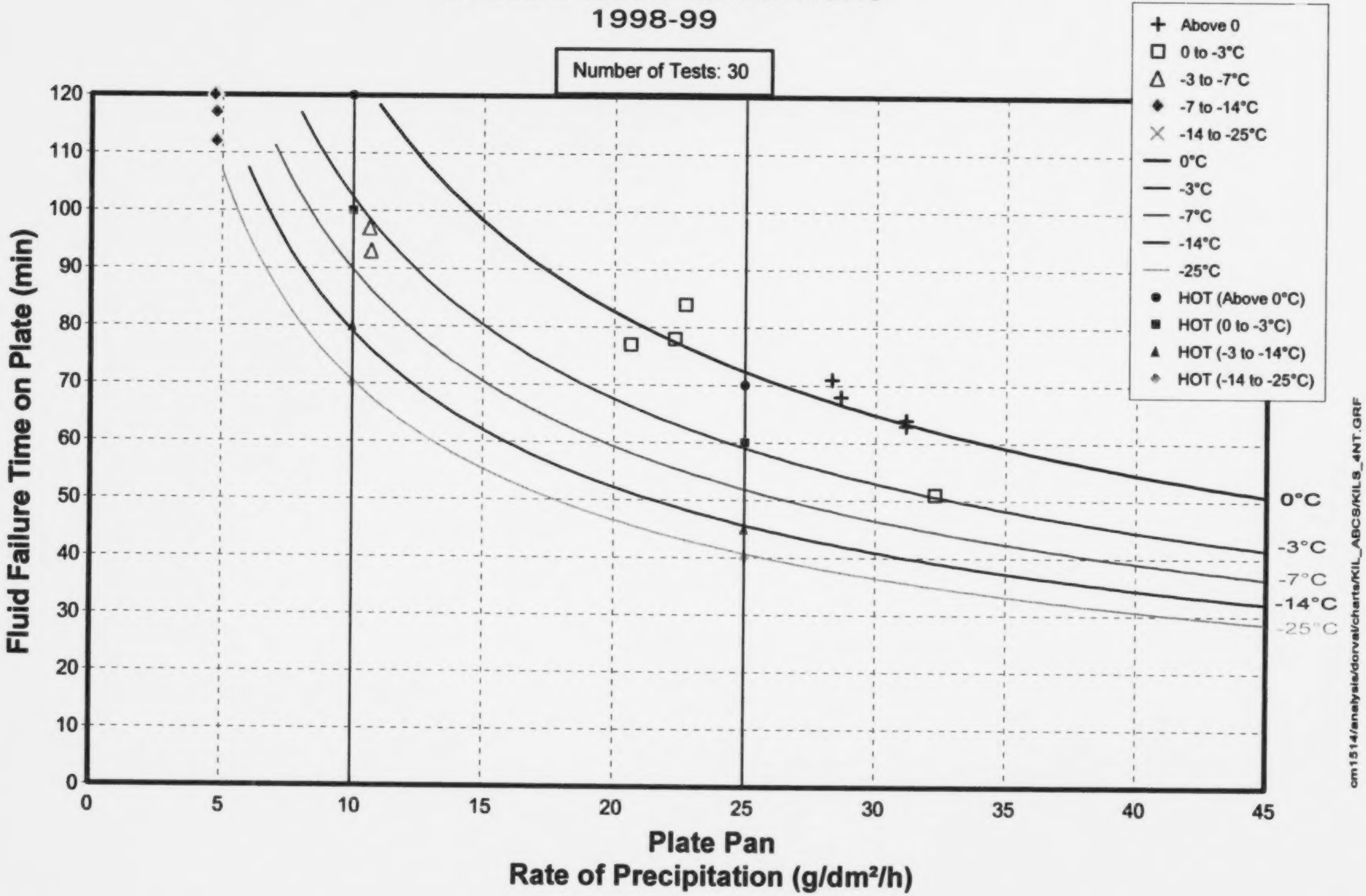
EFFECT OF TEMPERATURE AND RATE OF PRECIPITATION ON ENDURANCE TIME

FLUID X
NATURAL SNOW CONDITIONS
1998-99



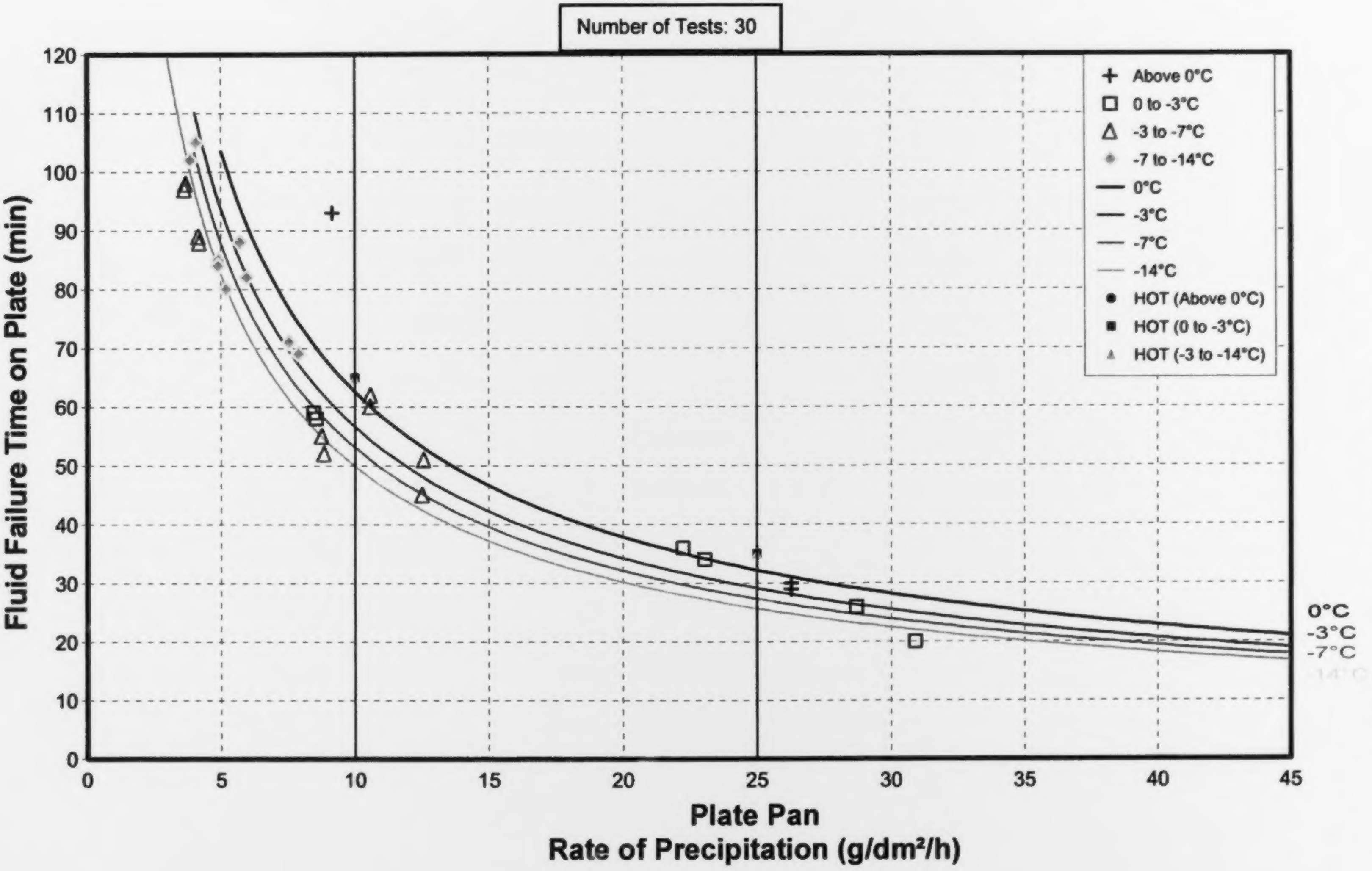
EFFECT OF TEMPERATURE AND RATE OF PRECIPITATION ON ENDURANCE TIME

KILFROST ABC-S TYPE IV NEAT
NATURAL SNOW CONDITIONS
1998-99



EFFECT OF TEMPERATURE AND RATE OF PRECIPITATION ON ENDURANCE TIME

KILFROST ABC-S TYPE IV 75/25
NATURAL SNOW CONDITIONS
1998-99



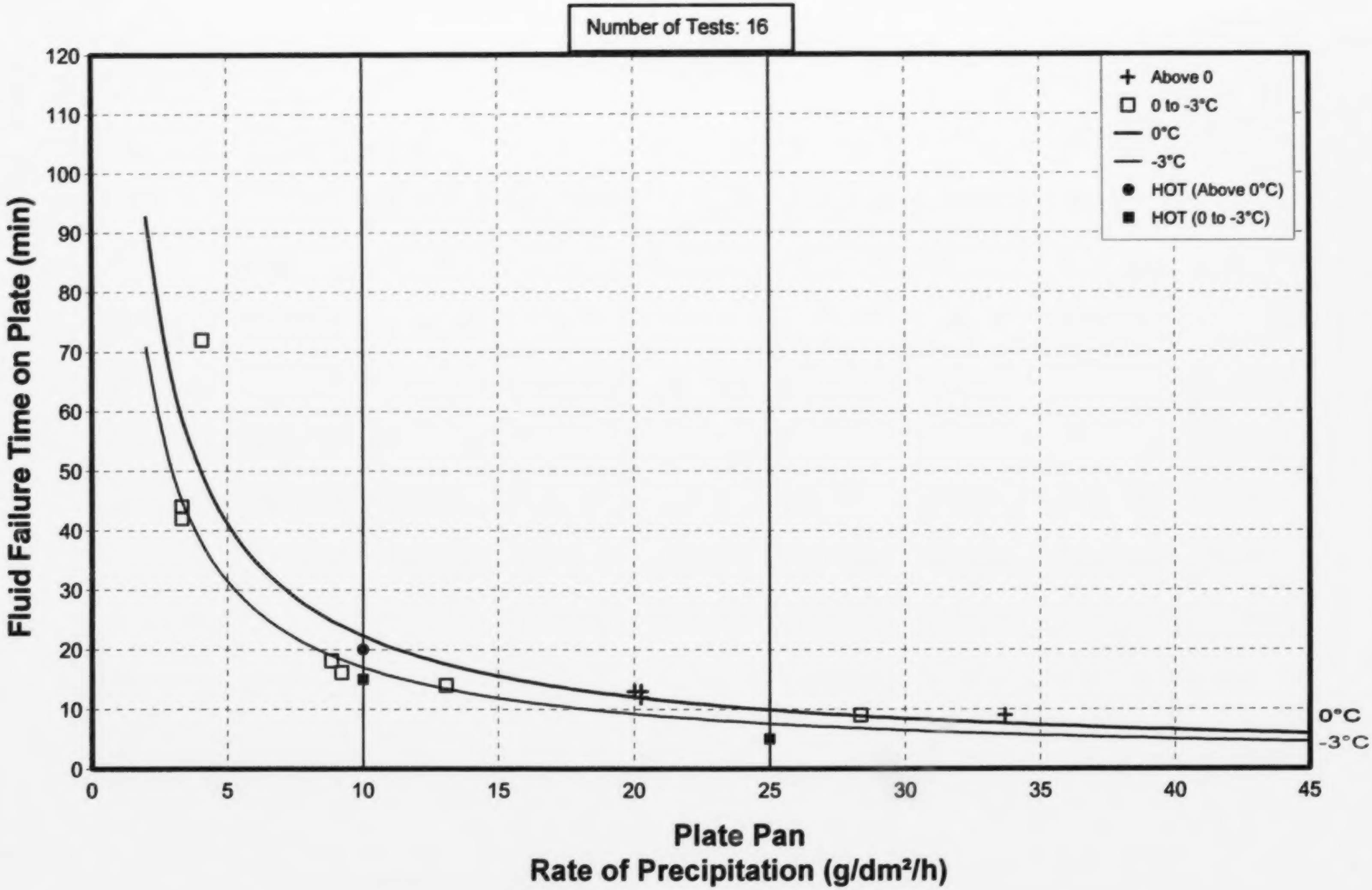
cm1514/analysis/dorval/charts/KIL_ABCS/KILS_47.GRF

EFFECT OF TEMPERATURE AND RATE OF PRECIPITATION ON ENDURANCE TIME

KILFROST ABC-S TYPE IV 50/50

NATURAL SNOW CONDITIONS

1998-99



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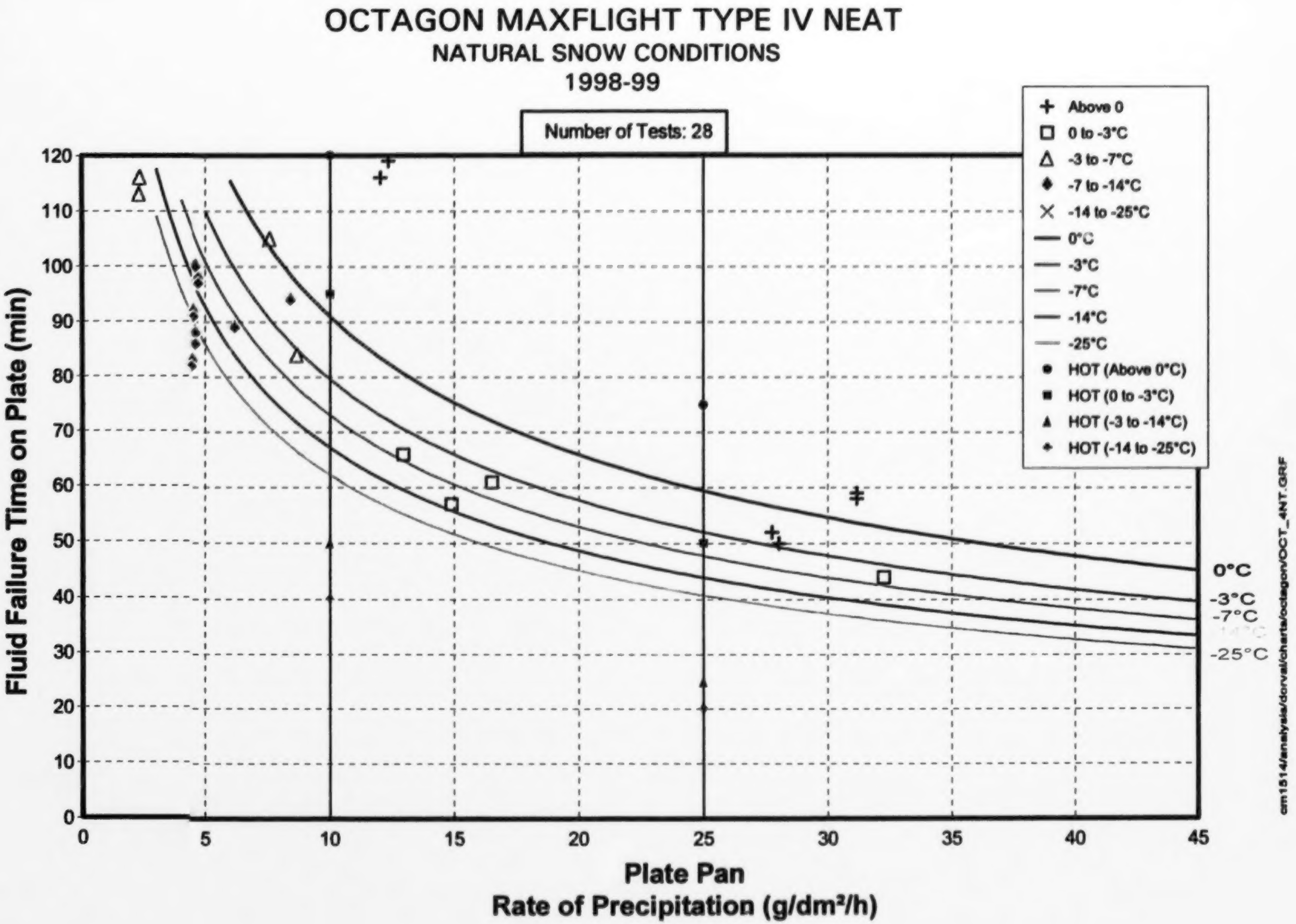
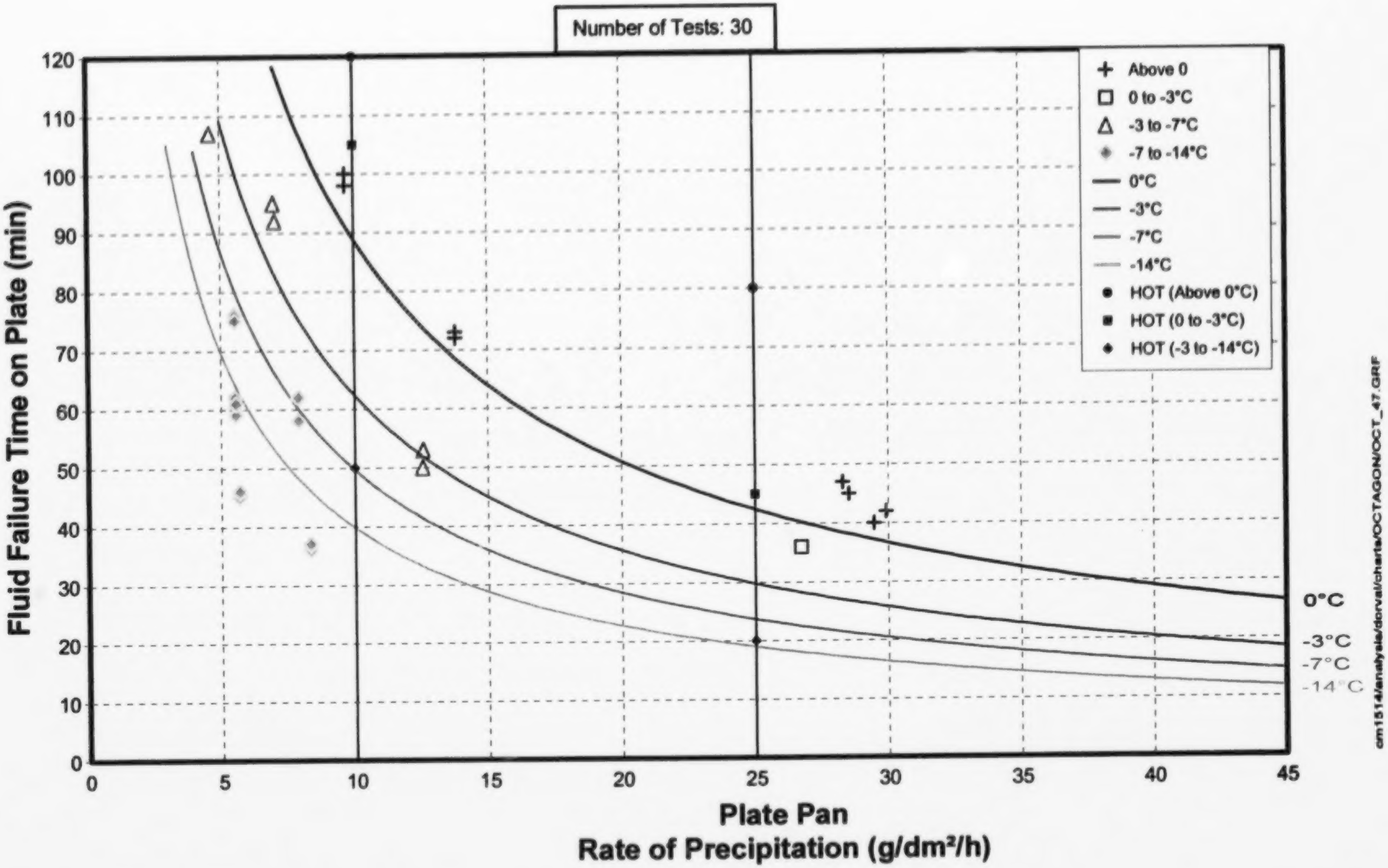

OCTAGON MAXFLIGHT TYPE IV NEAT
NATURAL SNOW CONDITIONS
1998-99
Number of Tests: 28
+ Above 0
□ 0 to -3°C
△ -3 to -7°C
♦ -7 to -14°C
× -14 to -25°C
— 0°C
— -3°C
— -7°C
— -14°C
— -25°C
● HOT (Above 0°C)
■ HOT (0 to -3°C)
▲ HOT (-3 to -14°C)
✦ HOT (-14 to -25°C)
Fluid Failure Time on Plate (min)
0
10
20
30
40
50
60
70
80
90
100
110
120
0
5
10
15
20
25
30
35
40
45
0°C
-3°C
-7°C
-14°C
-25°C
Plate Pan
Rate of Precipitation (g/dm²/h)
cm1514/analysis/dorval/charts/octagon/OCT_4NT.GRF

EFFECT OF TEMPERATURE AND RATE OF PRECIPITATION ON ENDURANCE TIME

OCTAGON MAXFLIGHT TYPE IV 75/25

NATURAL SNOW CONDITIONS

1998/99



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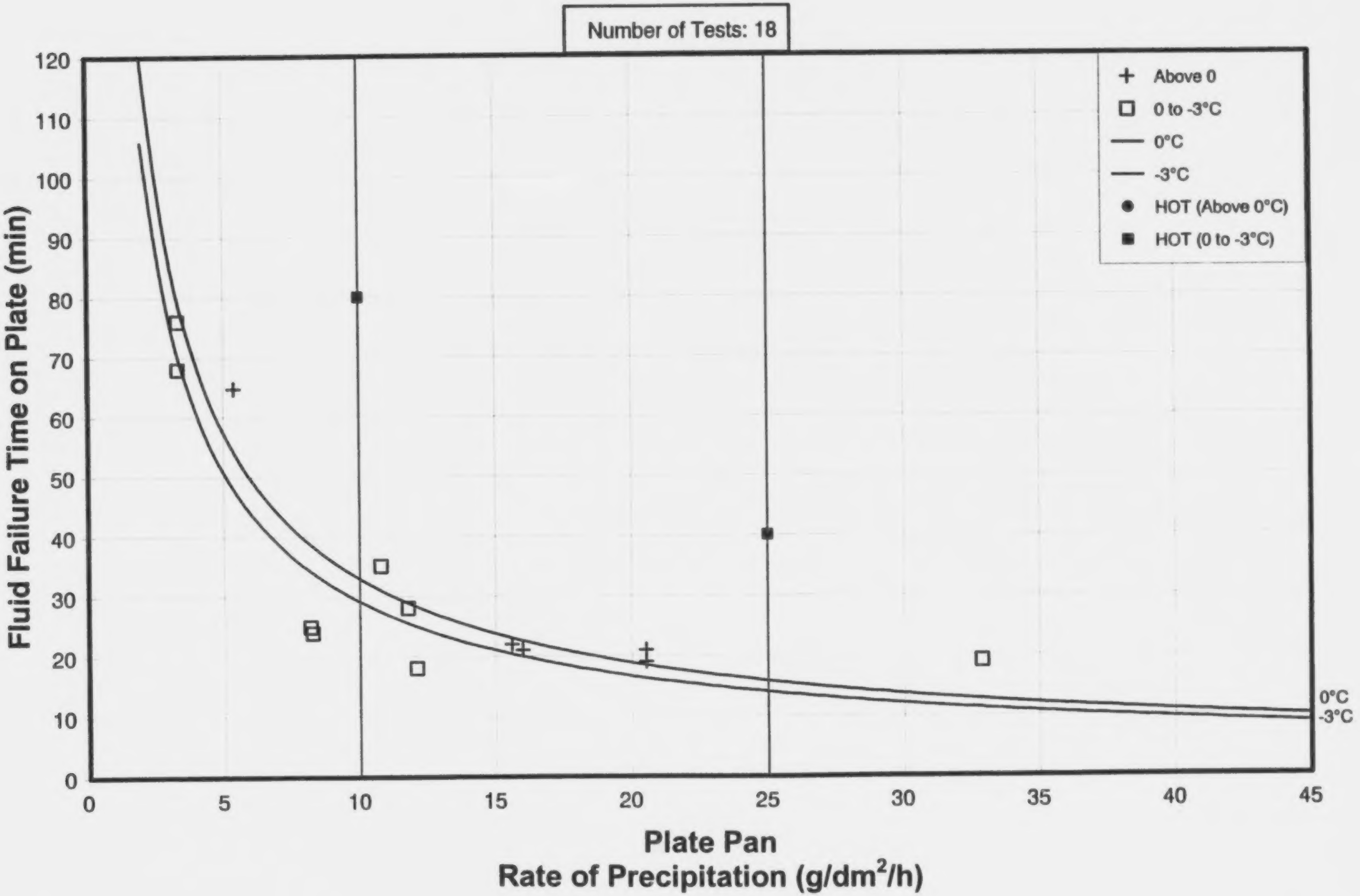
EFFECT OF TEMPERATURE AND RATE OF PRECIPITATION ON ENDURANCE TIME

OCTAGON MAXFLIGHT TYPE IV 50/50

NATURAL SNOW CONDITIONS

1998-99



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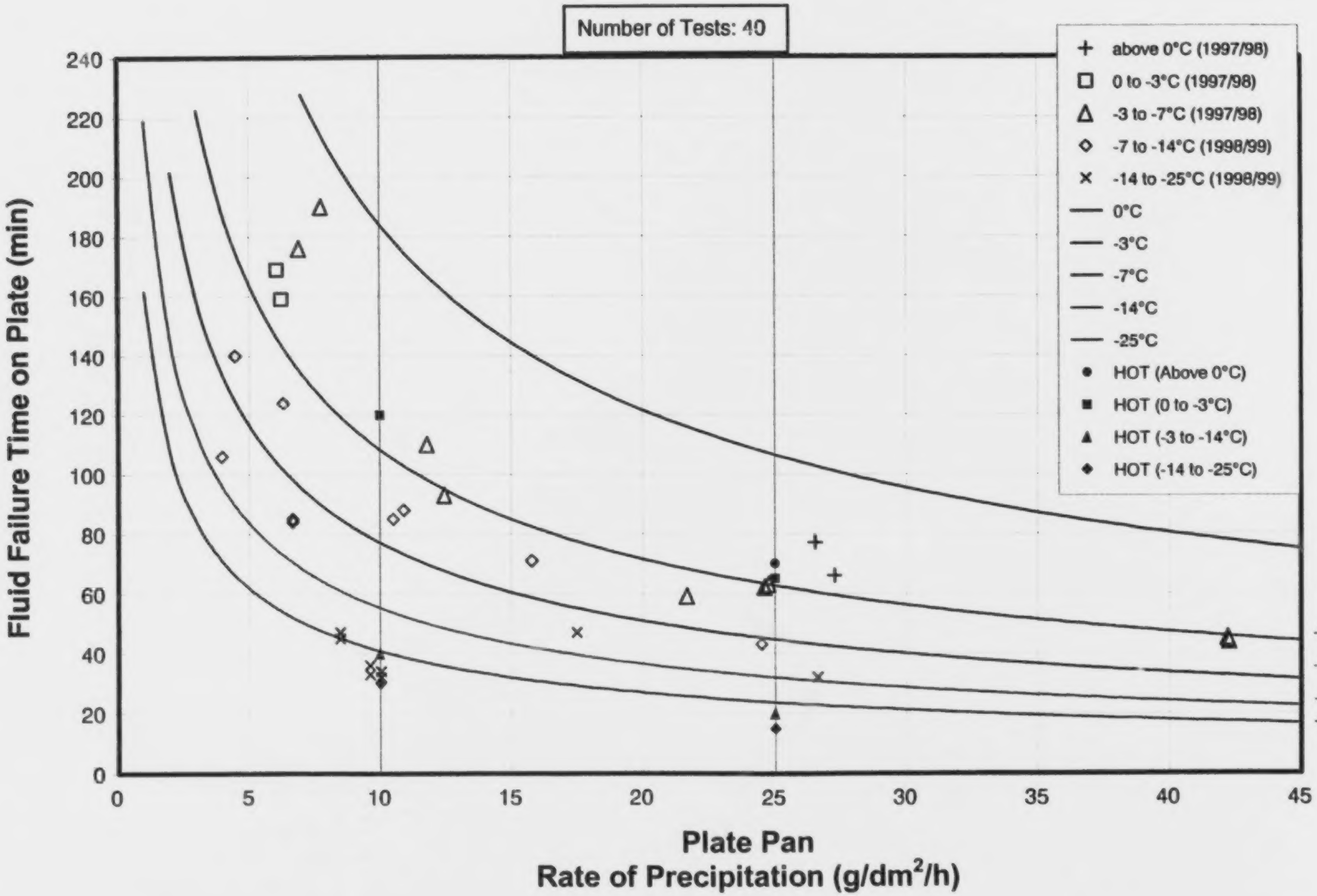
SPCA AD-480 TYPE IV NEAT

NATURAL SNOW CONDITIONS

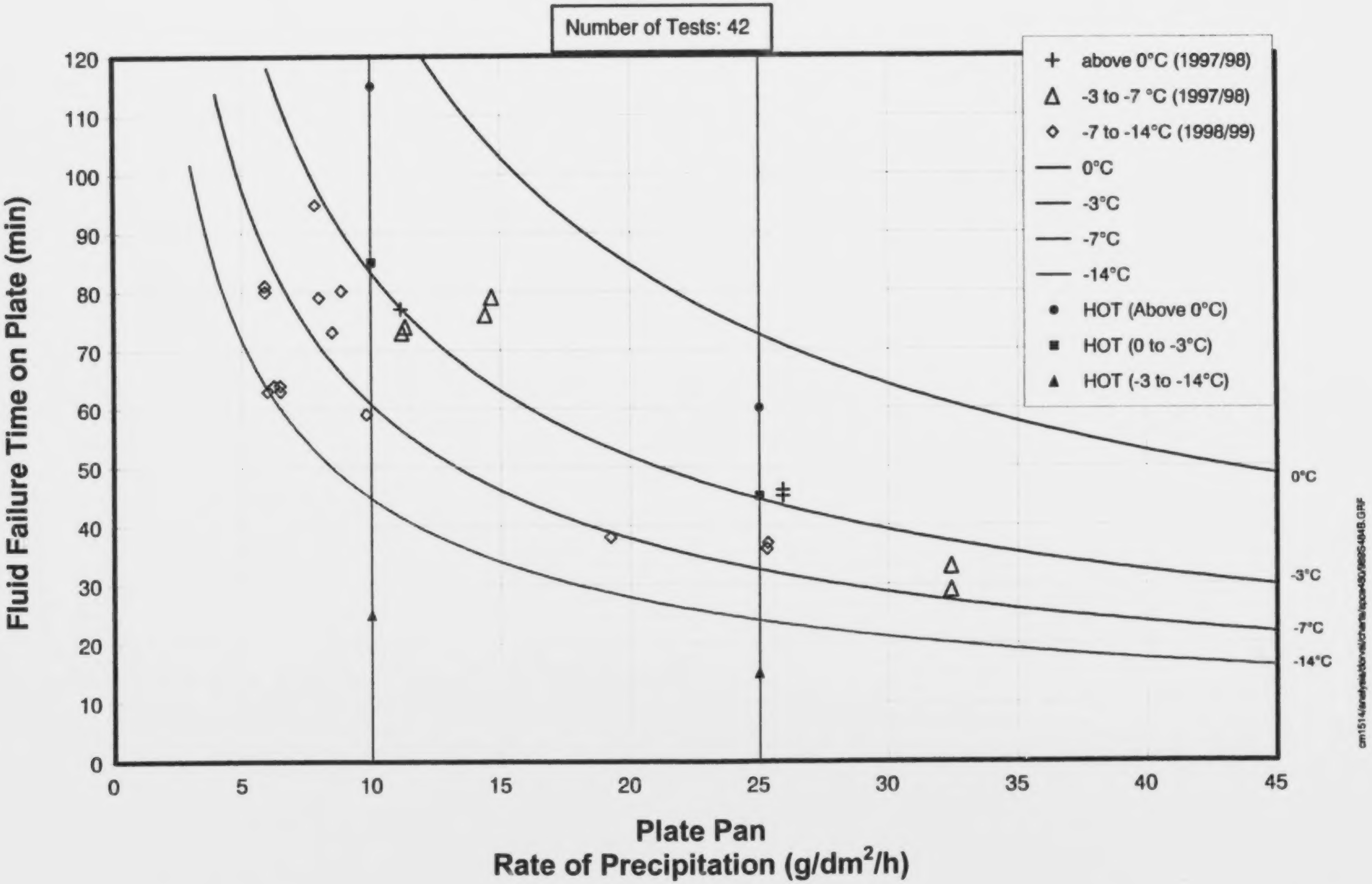
1997-98 and 1998-99



SPCA AD-480 TYPE IV 75/25

NATURAL SNOW CONDITIONS

1997-98 and 1998-99

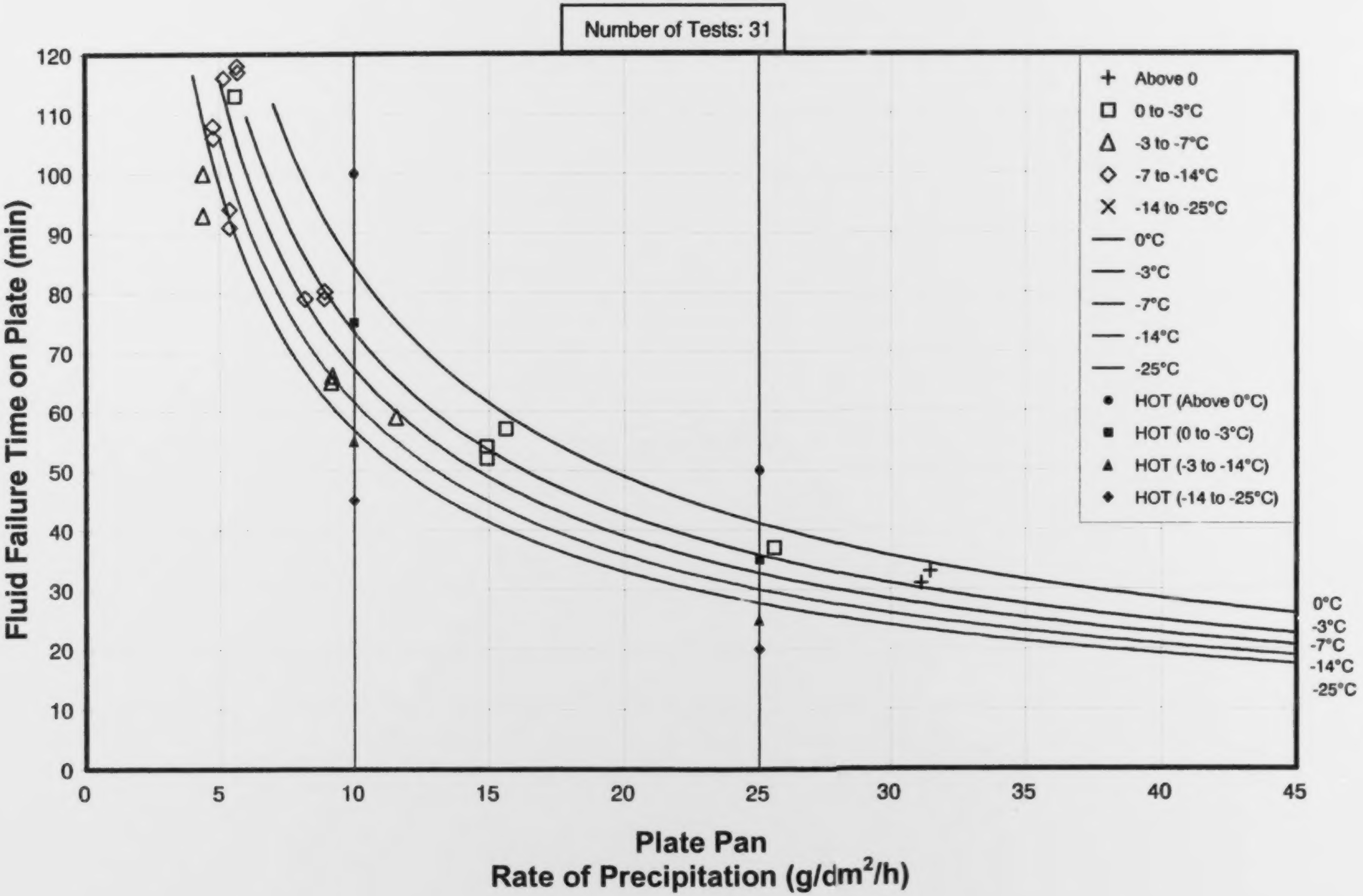


EFFECT OF TEMPERATURE AND RATE OF PRECIPITATION ON ENDURANCE TIME

UCAR ULTRA+ TYPE IV NEAT

NATURAL SNOW CONDITIONS

1998-99



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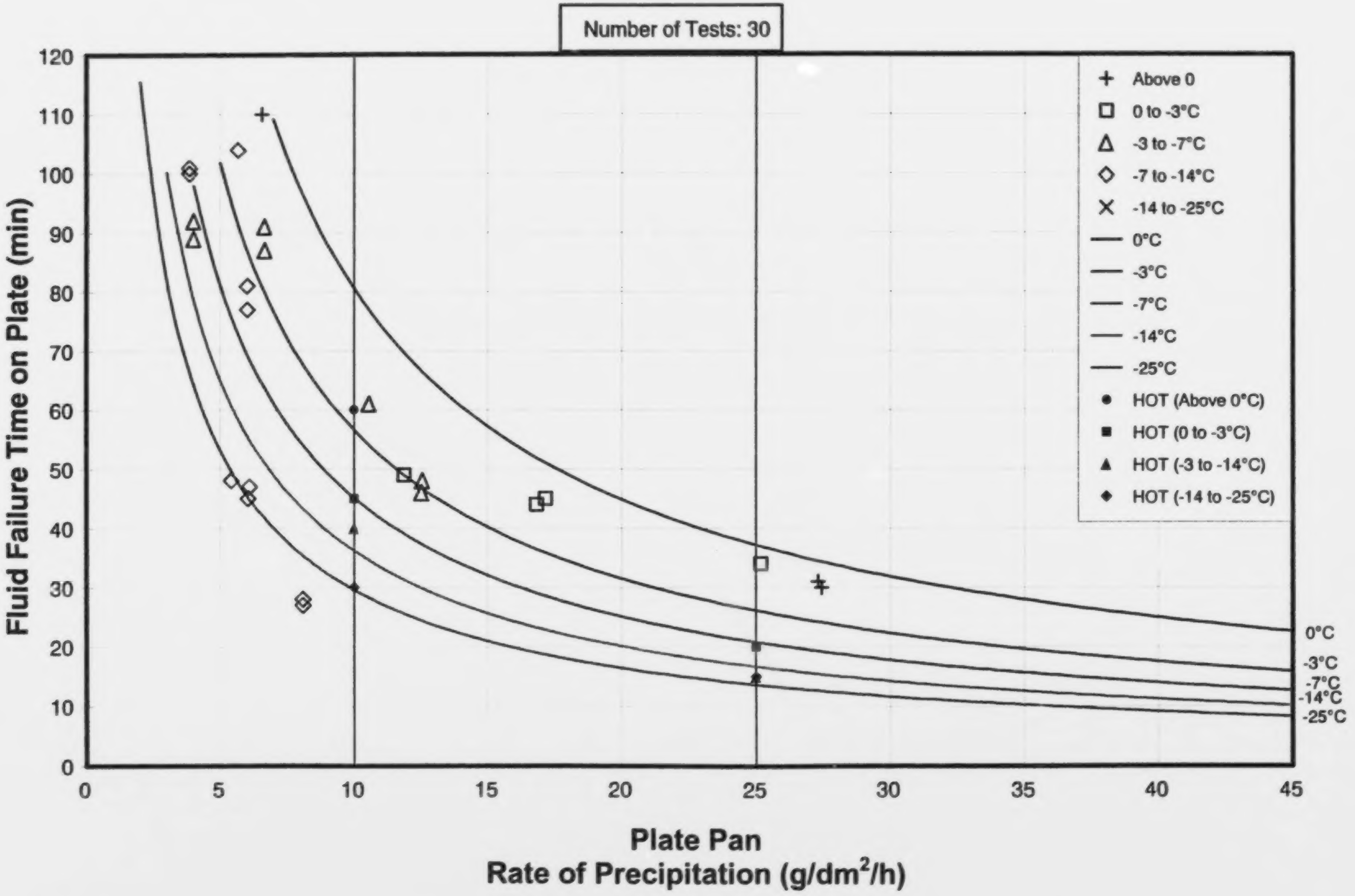
EFFECT OF TEMPERATURE AND RATE OF PRECIPITATION ON ENDURANCE TIME

KILFROST ABC-II PLUS NEAT

NATURAL SNOW CONDITIONS

1998-99



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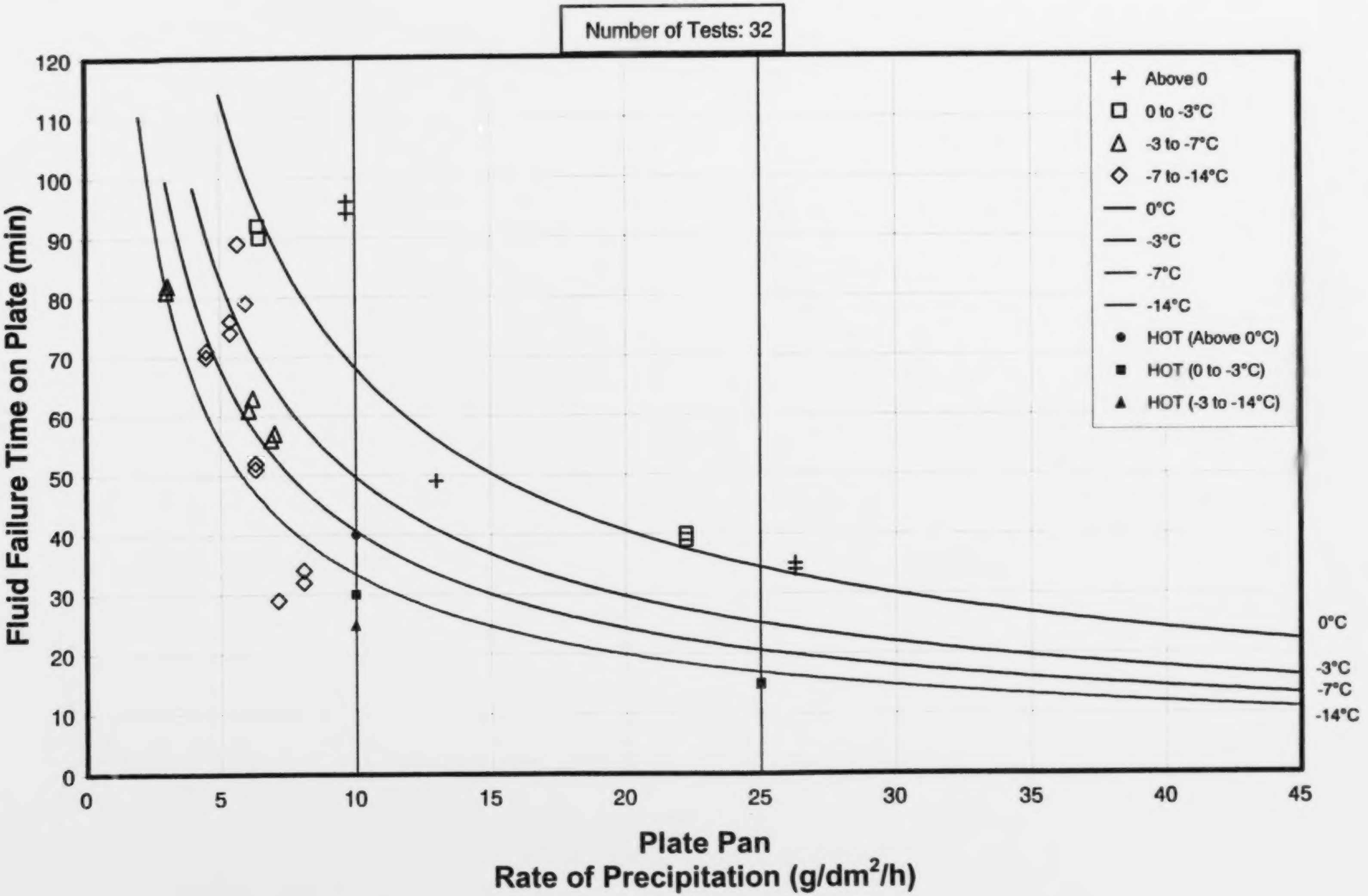
EFFECT OF TEMPERATURE AND RATE OF PRECIPITATION ON ENDURANCE TIME

KILFROST ABC-II PLUS 75/25

NATURAL SNOW CONDITIONS

1998-99

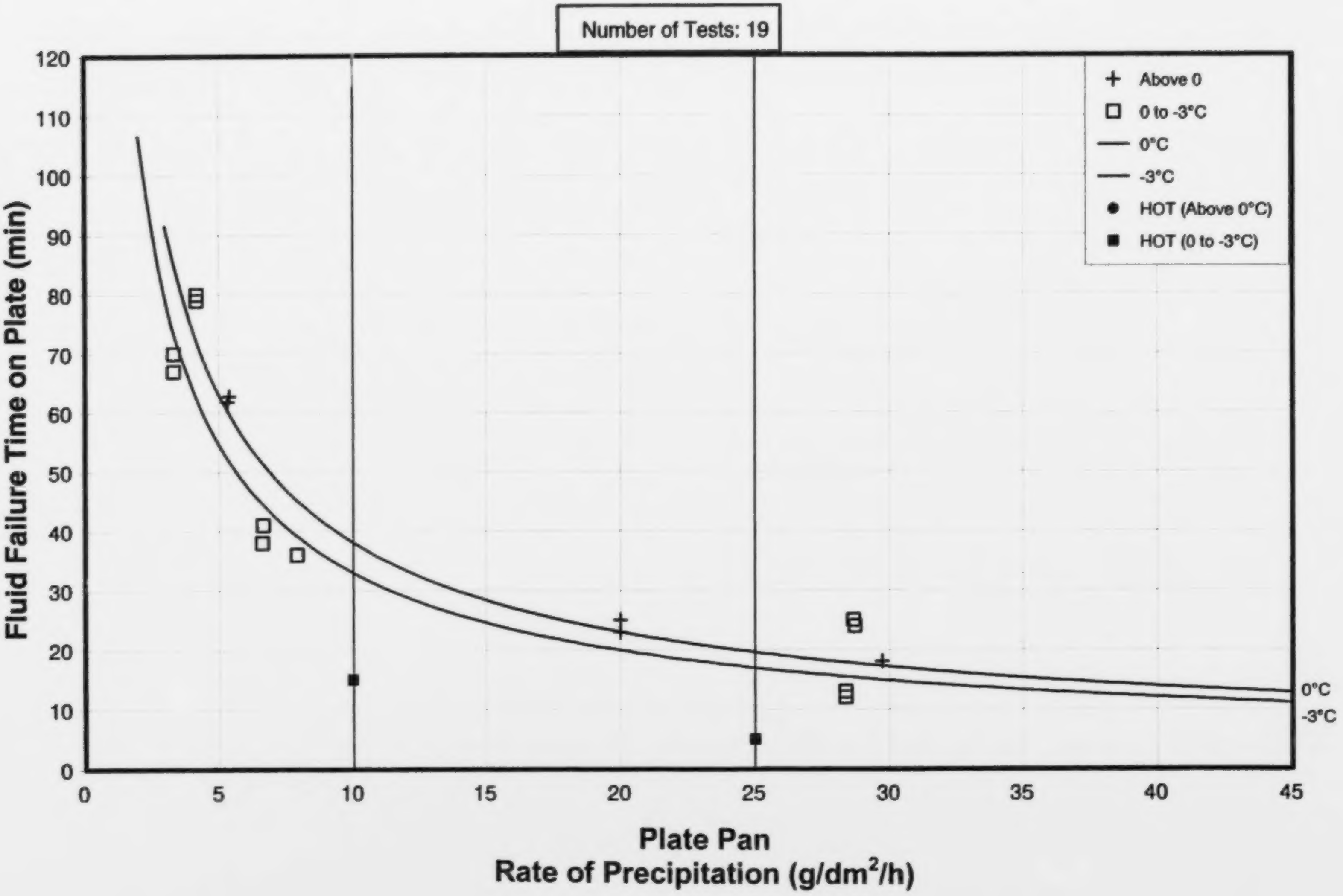


EFFECT OF TEMPERATURE AND RATE OF PRECIPITATION ON ENDURANCE TIME

KILFROST ABC-II PLUS 50/50

NATURAL SNOW CONDITIONS

1998-99

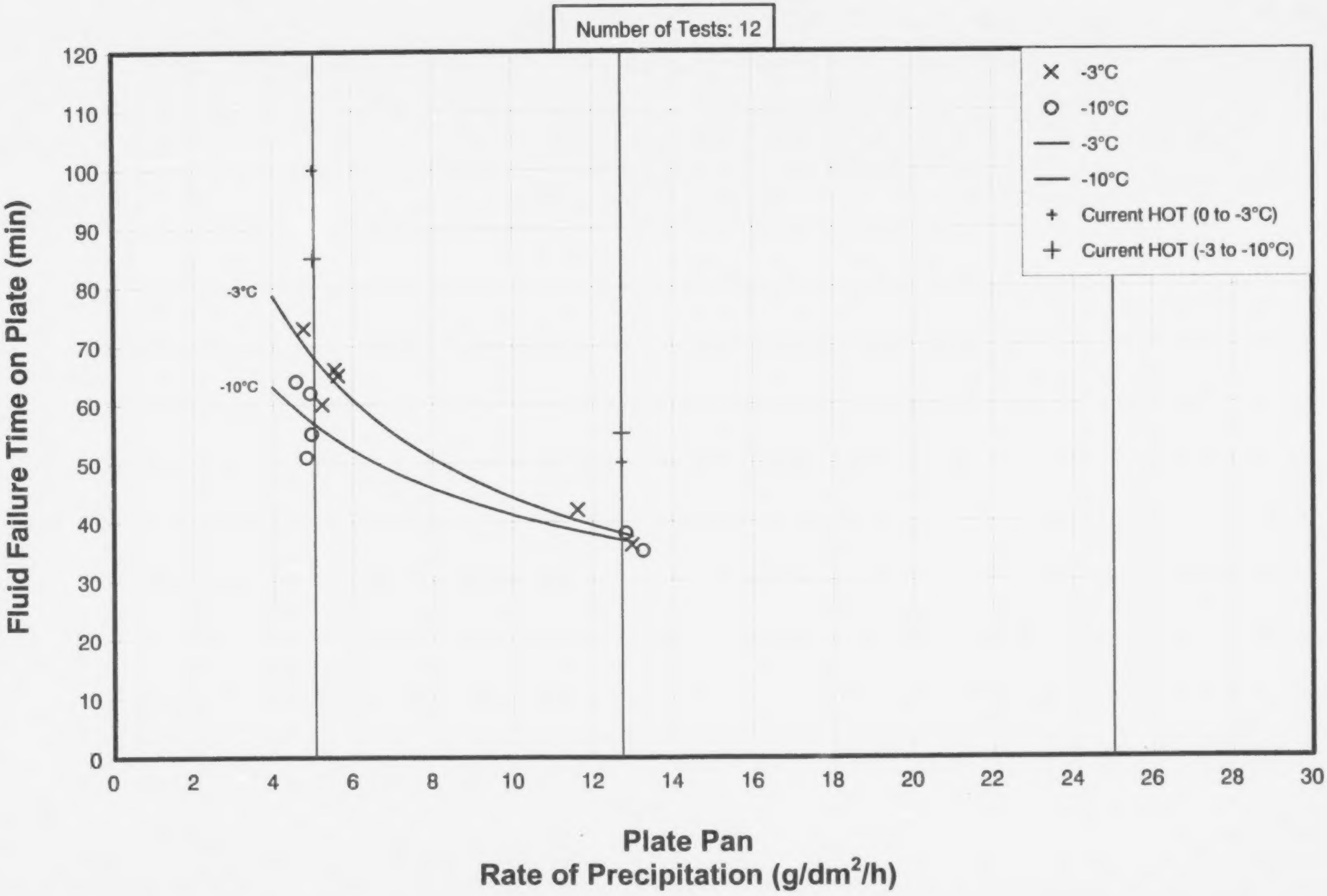


EFFECT OF TEMPERATURE AND RATE OF PRECIPITATION ON ENDURANCE TIME

CLARIANT SAFEWING MPIV 1957 TYPE IV NEAT

SIMULATED FREEZING DRIZZLE

1998-99



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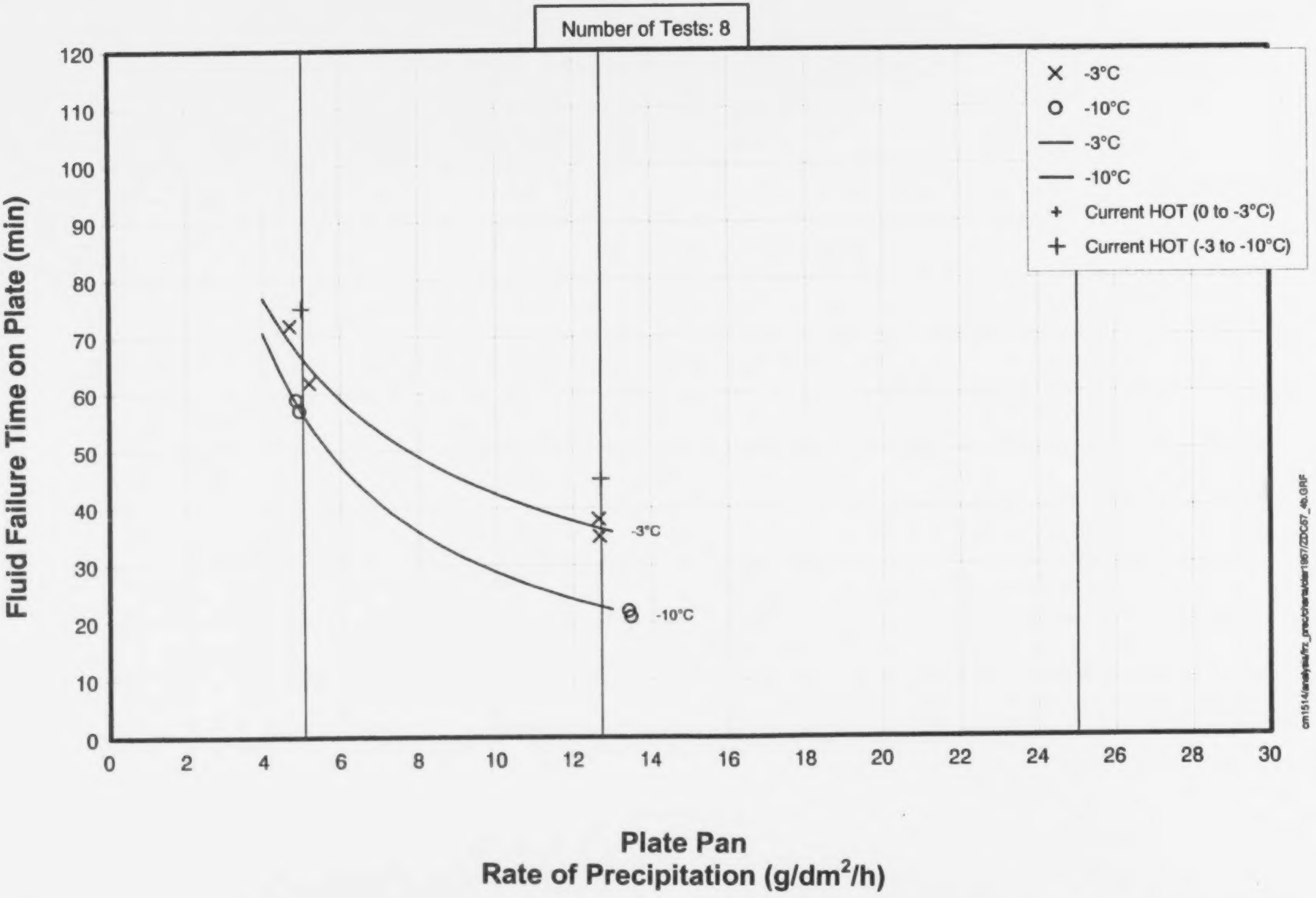
CLARIANT SAFEWING MPIV 1957 TYPE IV 75/25

SIMULATED FREEZING DRIZZLE

1998-99

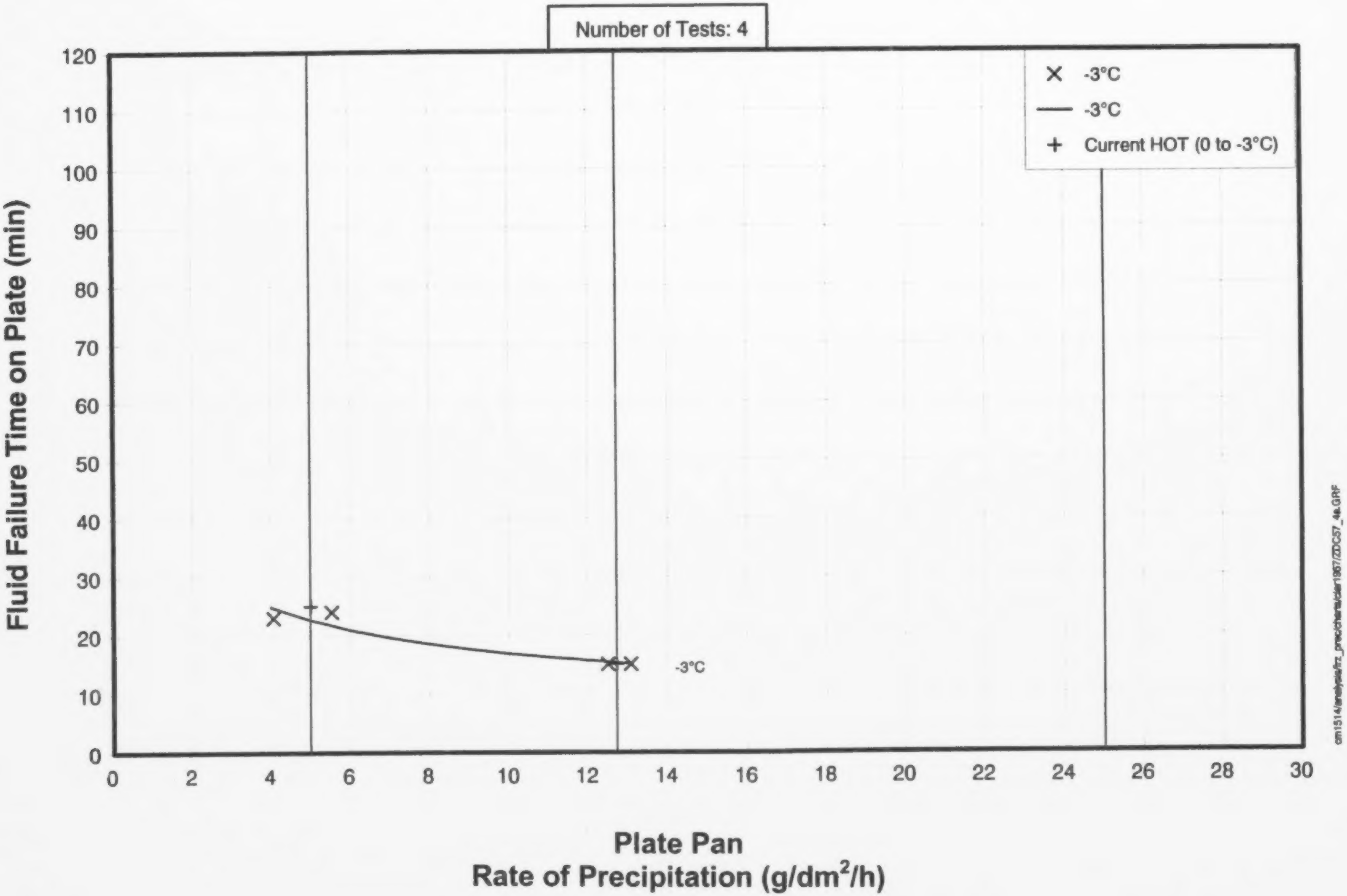


EFFECT OF TEMPERATURE AND RATE OF PRECIPITATION ON ENDURANCE TIME

CLARIANT SAFEWING MPIV 1957 TYPE IV 50/50

SIMULATED FREEZING DRIZZLE

1998-99

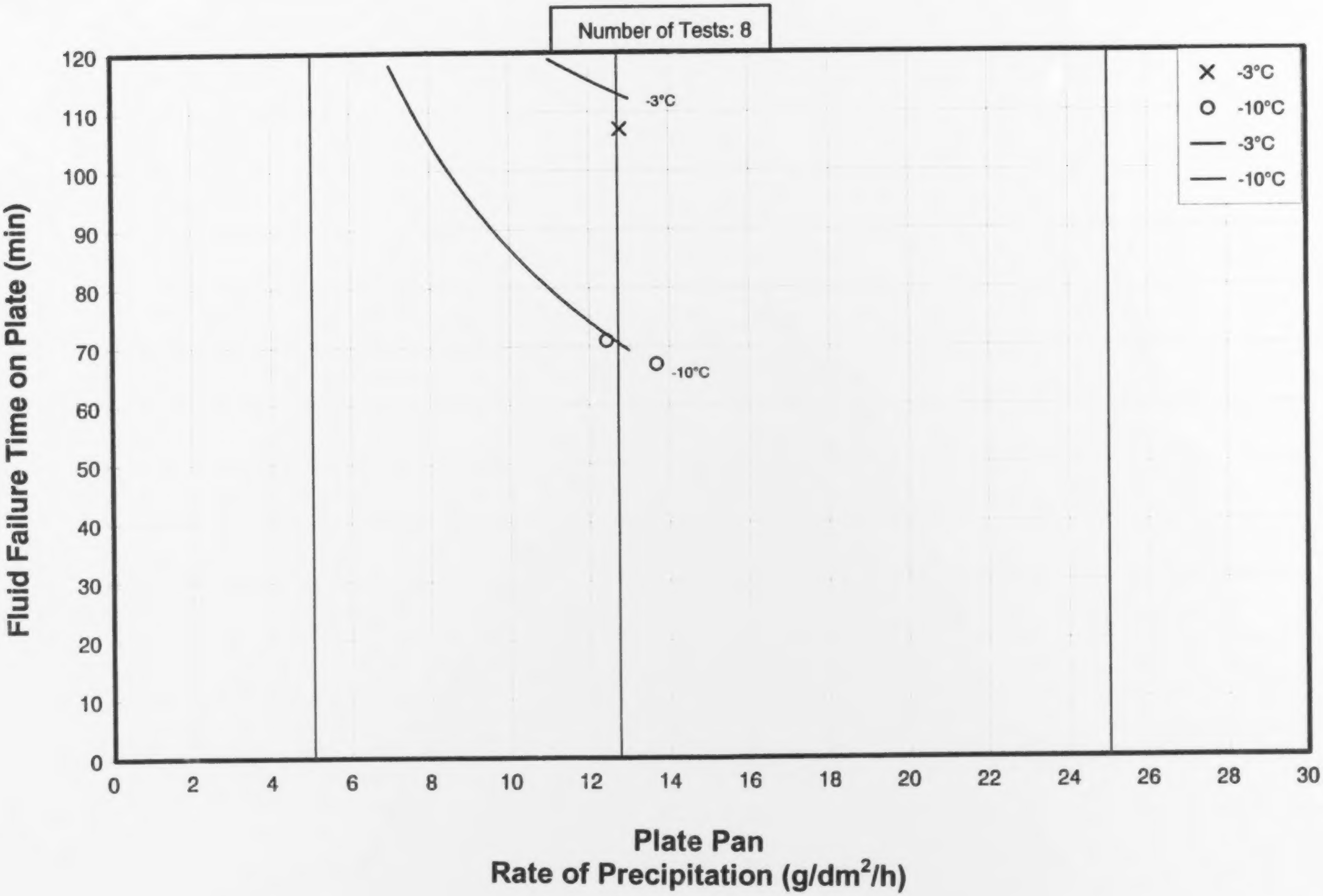


EFFECT OF TEMPERATURE AND RATE OF PRECIPITATION ON ENDURANCE TIME

FLUID X

SIMULATED FREEZING DRIZZLE

1998-99



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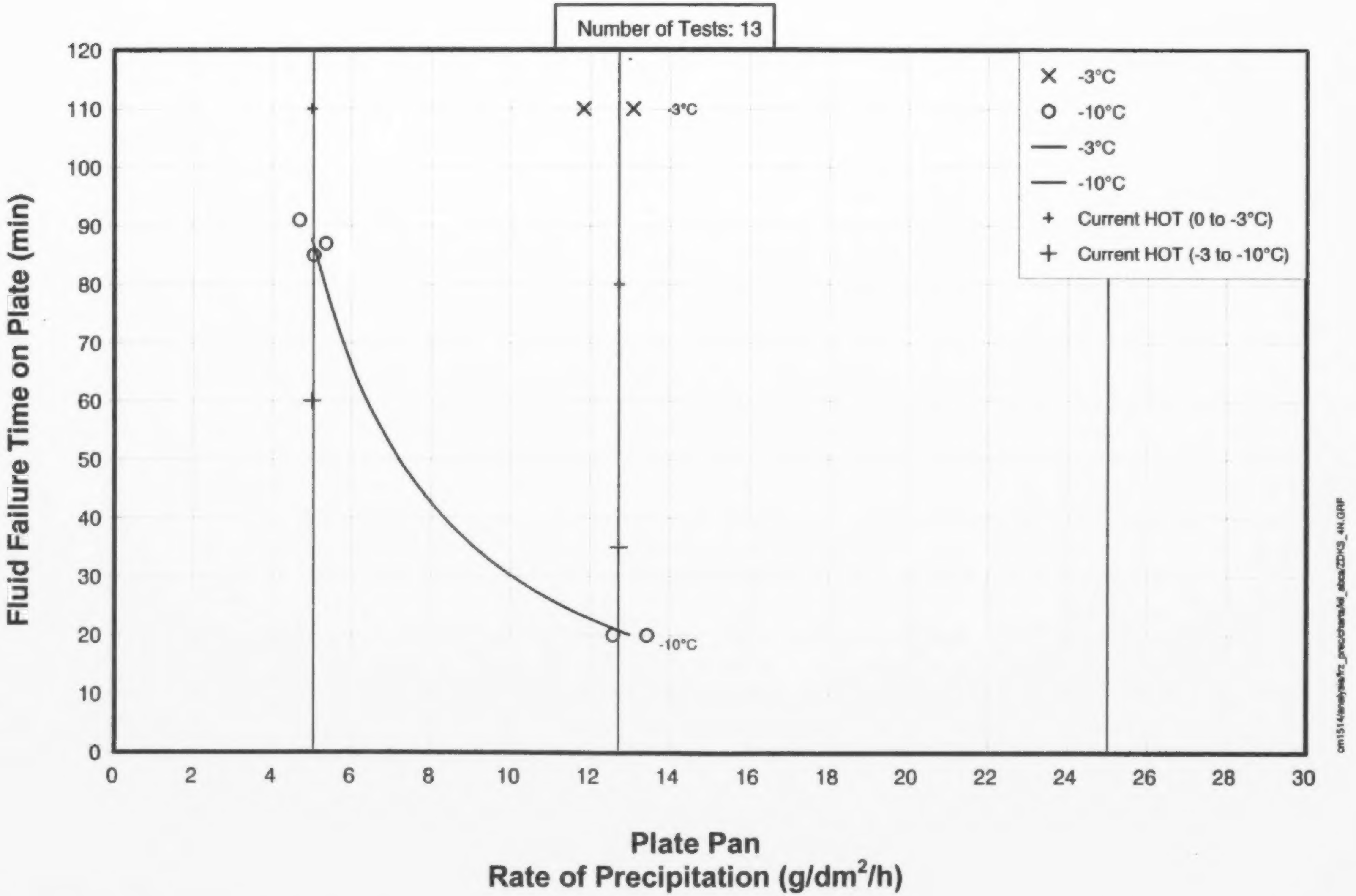
EFFECT OF TEMPERATURE AND RATE OF PRECIPITATION ON ENDURANCE TIME

KILFROST ABC-S TYPE IV NEAT

SIMULATED FREEZING DRIZZLE

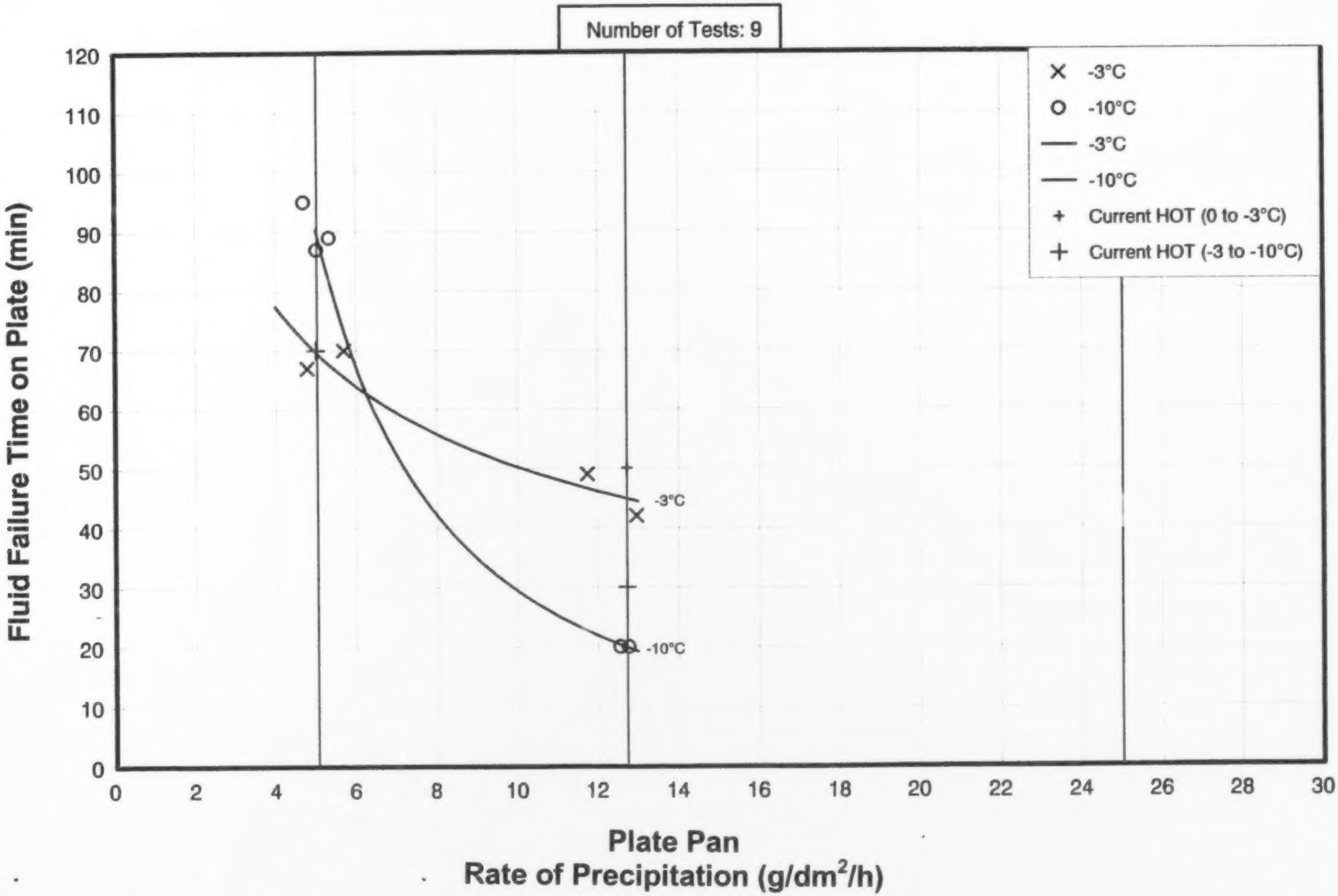
1998-99



KILFROST ABC-S TYPE IV 75/25

SIMULATED FREEZING DRIZZLE

1998-99



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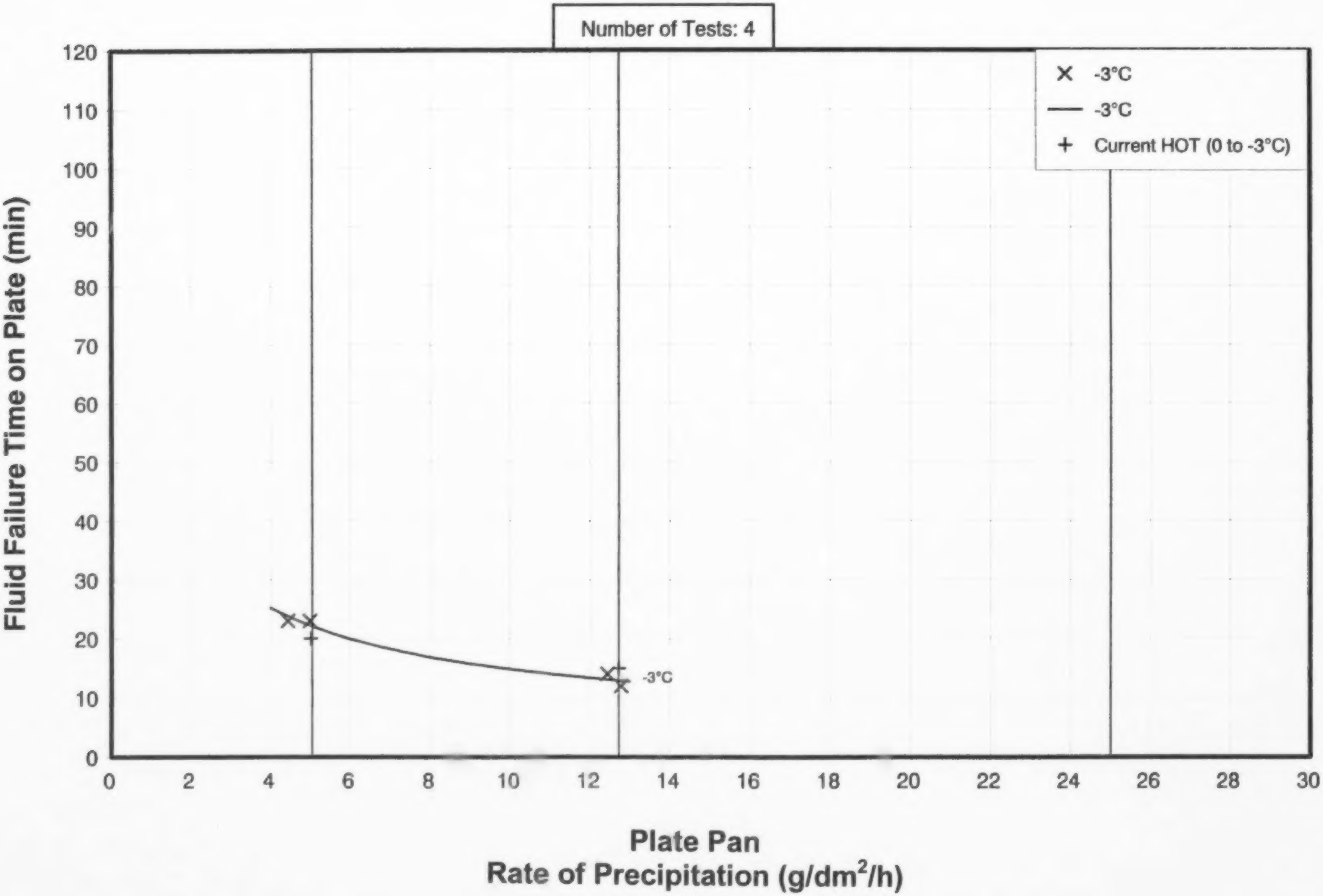
EFFECT OF TEMPERATURE AND RATE OF PRECIPITATION ON ENDURANCE TIME

KILFROST ABC-S TYPE IV 50/50

SIMULATED FREEZING DRIZZLE

1998-99



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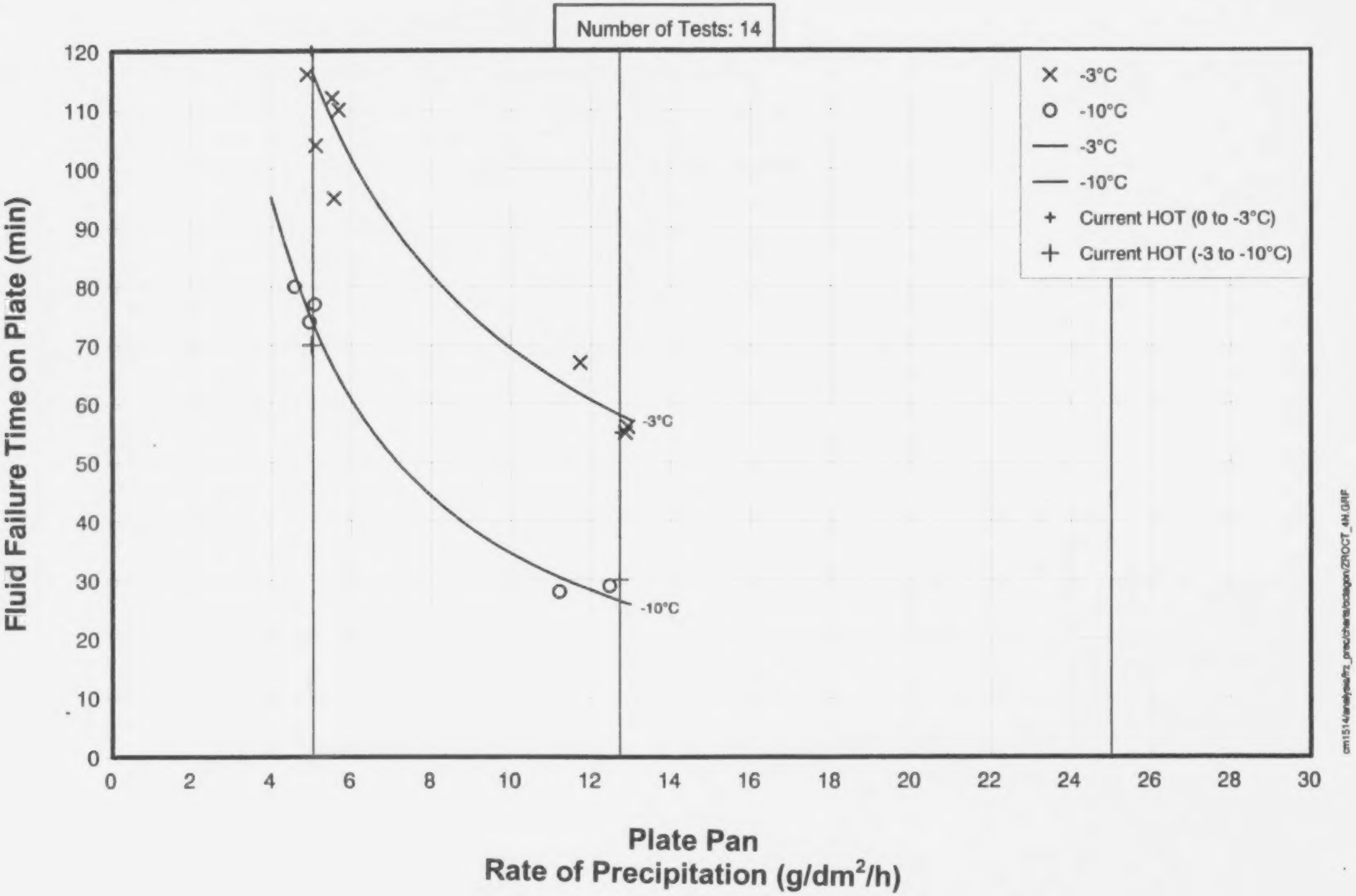
EFFECT OF TEMPERATURE AND RATE OF PRECIPITATION ON ENDURANCE TIME

OCTAGON MAXFLIGHT TYPE IV NEAT

SIMULATED FREEZING DRIZZLE

1998-99

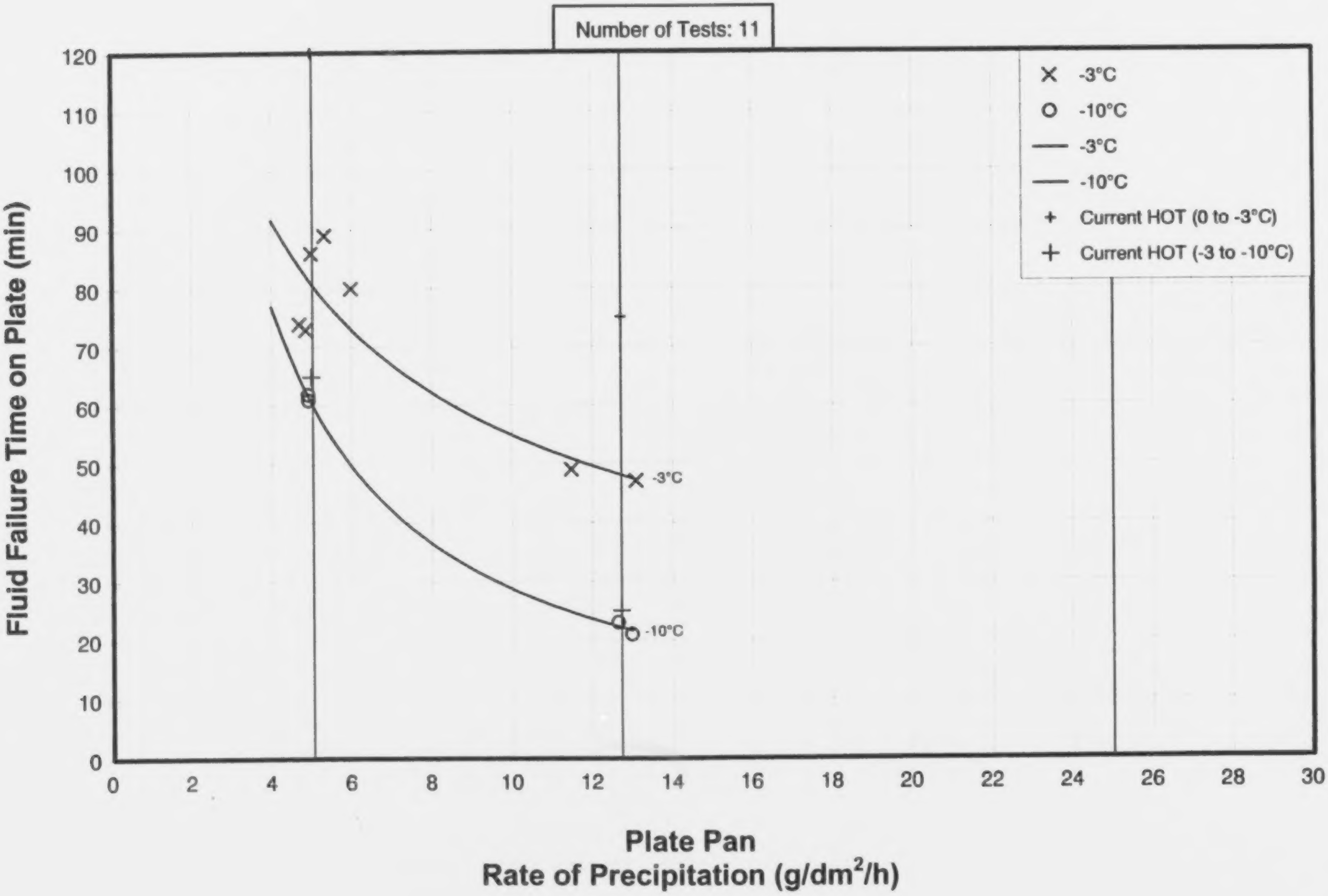


EFFECT OF TEMPERATURE AND RATE OF PRECIPITATION ON ENDURANCE TIME

OCTAGON MAXFLIGHT TYPE IV 75/25

SIMULATED FREEZING DRIZZLE

1998-99



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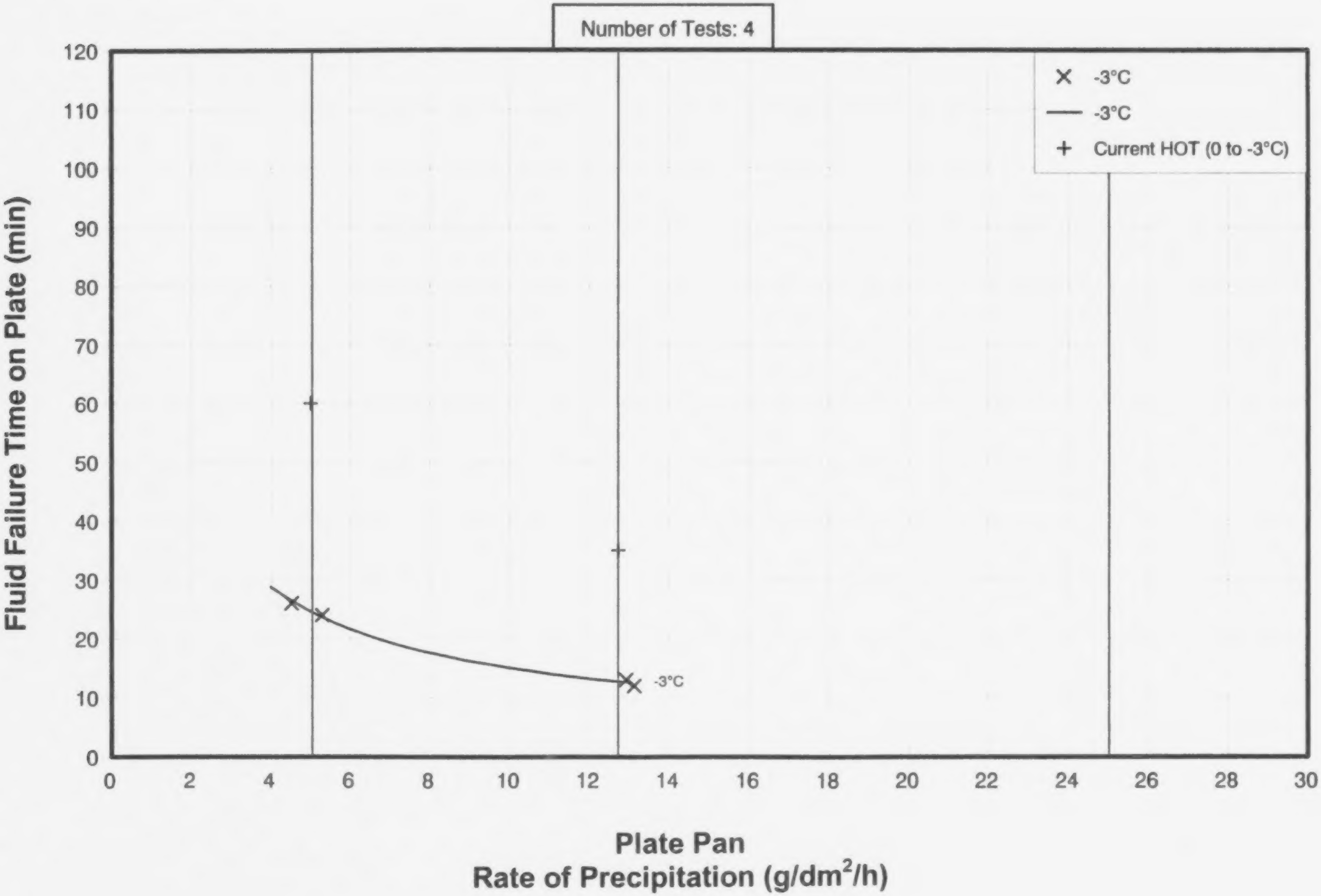
EFFECT OF TEMPERATURE AND RATE OF PRECIPITATION ON ENDURANCE TIME

OCTAGON MAXFLIGHT TYPE IV 50/50

SIMULATED FREEZING DRIZZLE

1998-99



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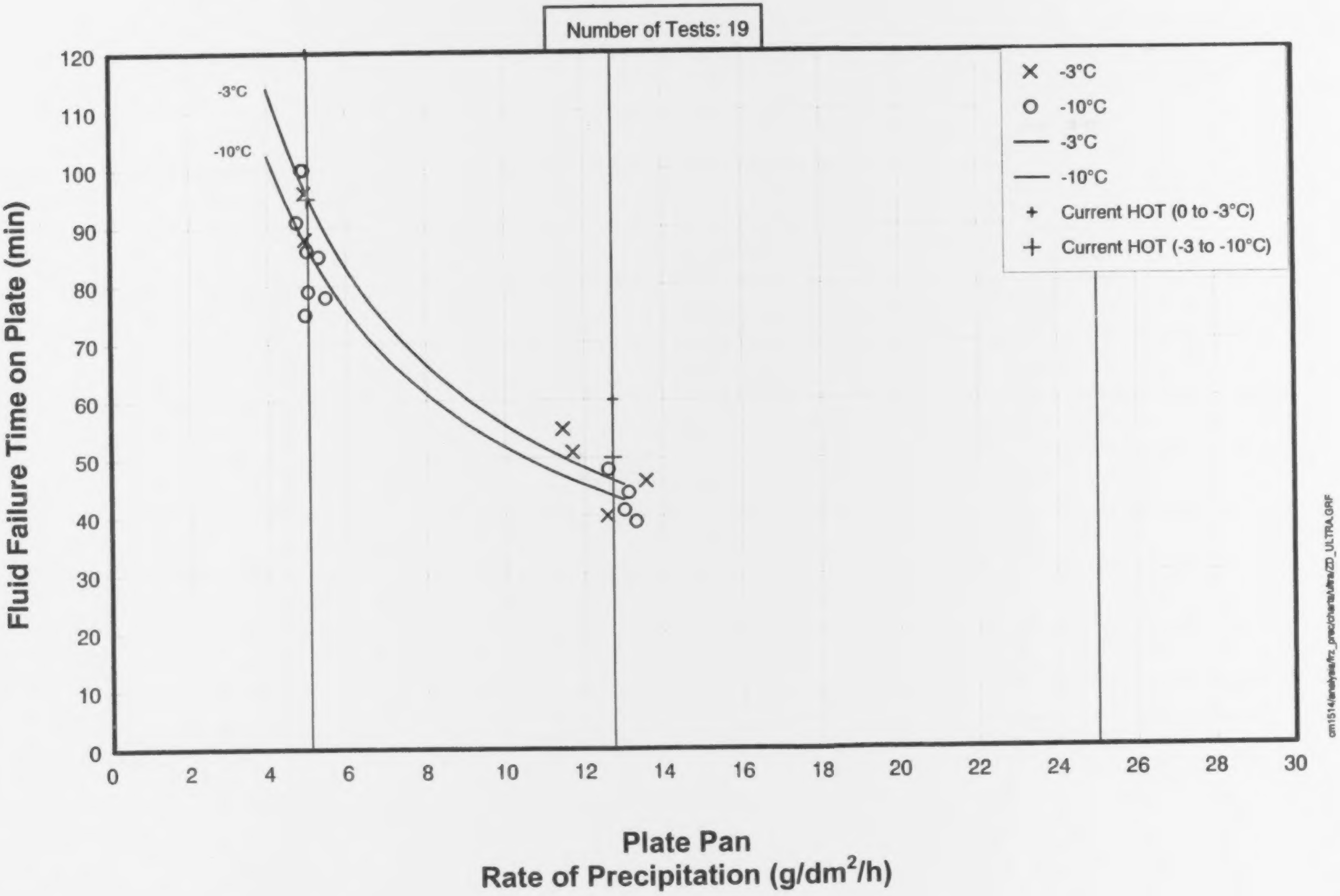
EFFECT OF TEMPERATURE AND RATE OF PRECIPITATION ON ENDURANCE TIME

UCAR ULTRA + TYPE IV NEAT

SIMULATED FREEZING DRIZZLE

1998-99

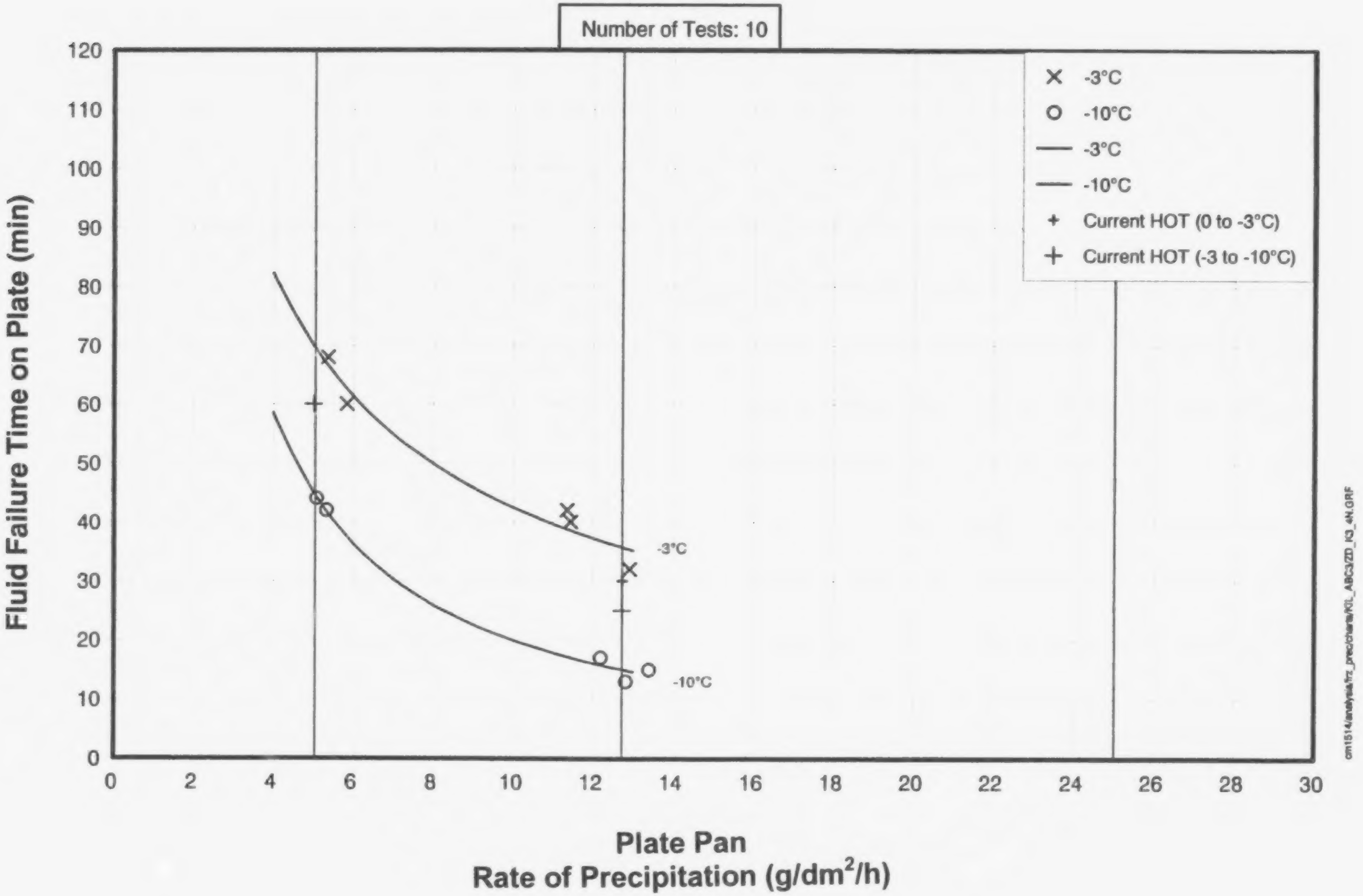


EFFECT OF TEMPERATURE AND RATE OF PRECIPITATION ON ENDURANCE TIME

KILFROST ABC-II PLUS NEAT

SIMULATED FREEZING DRIZZLE

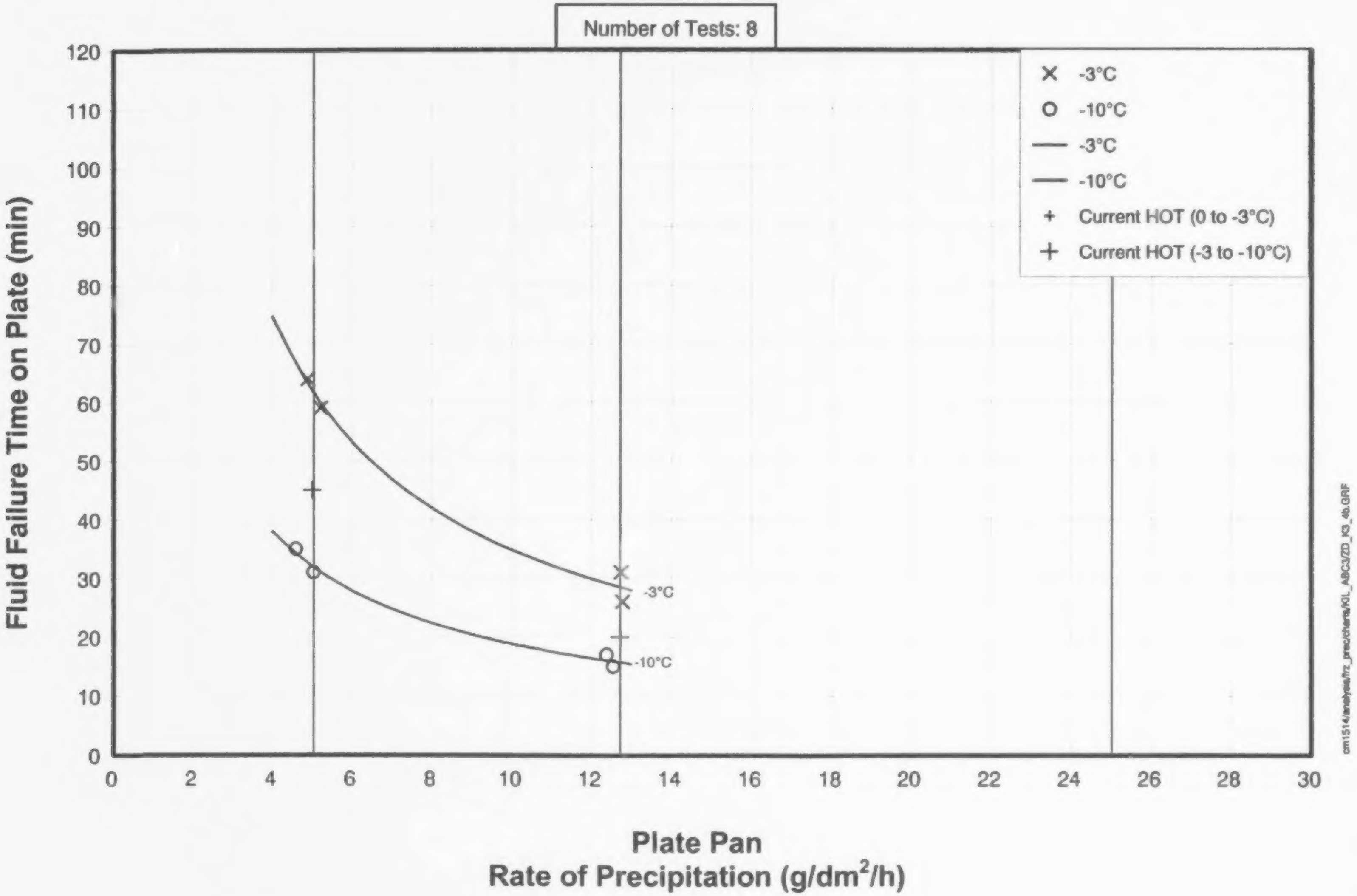
1998-99



KILFROST ABC-II PLUS 75/25

SIMULATED FREEZING DRIZZLE

1998-99

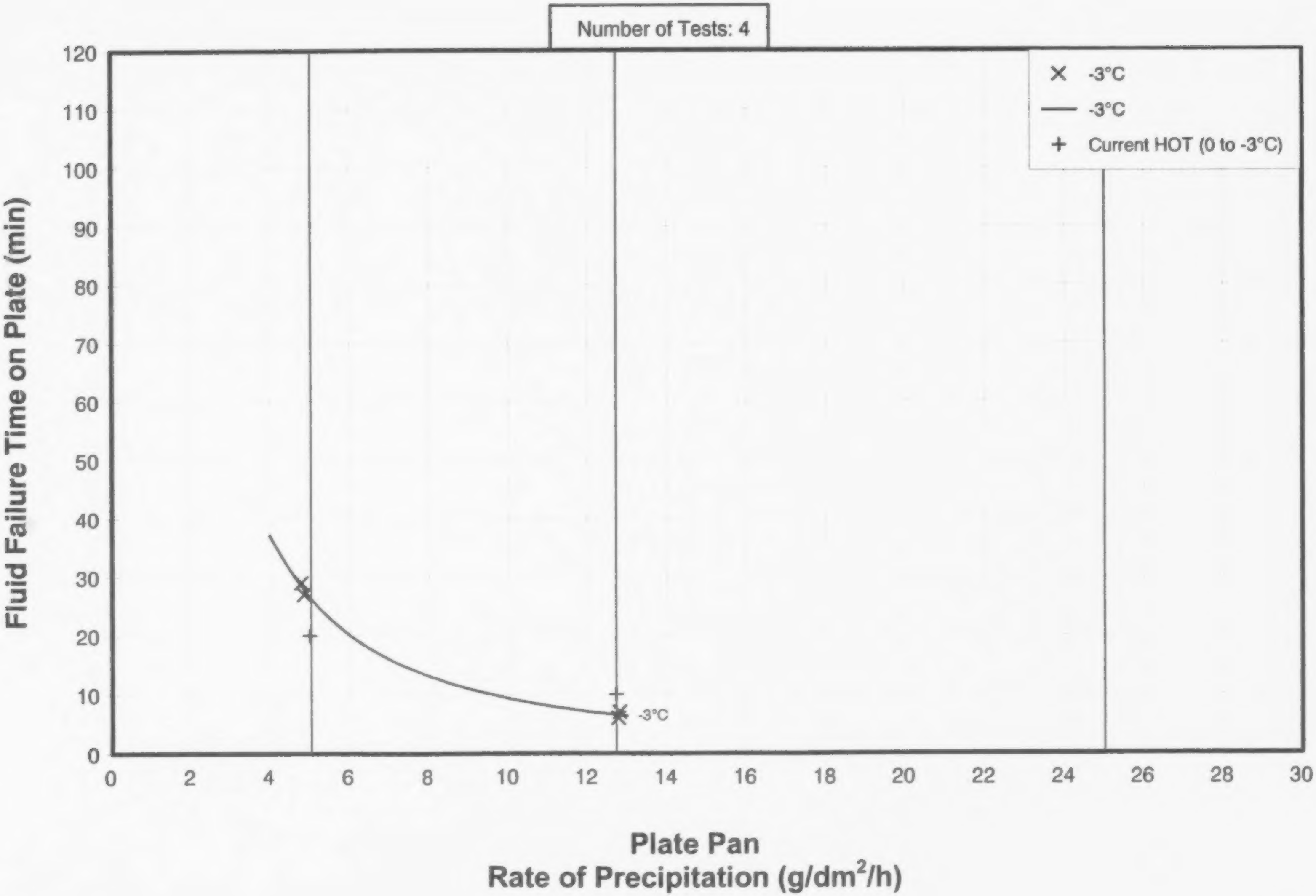


EFFECT OF TEMPERATURE AND RATE OF PRECIPITATION ON ENDURANCE TIME

KILFROST ABC-II PLUS 50/50

SIMULATED FREEZING DRIZZLE

1998-99



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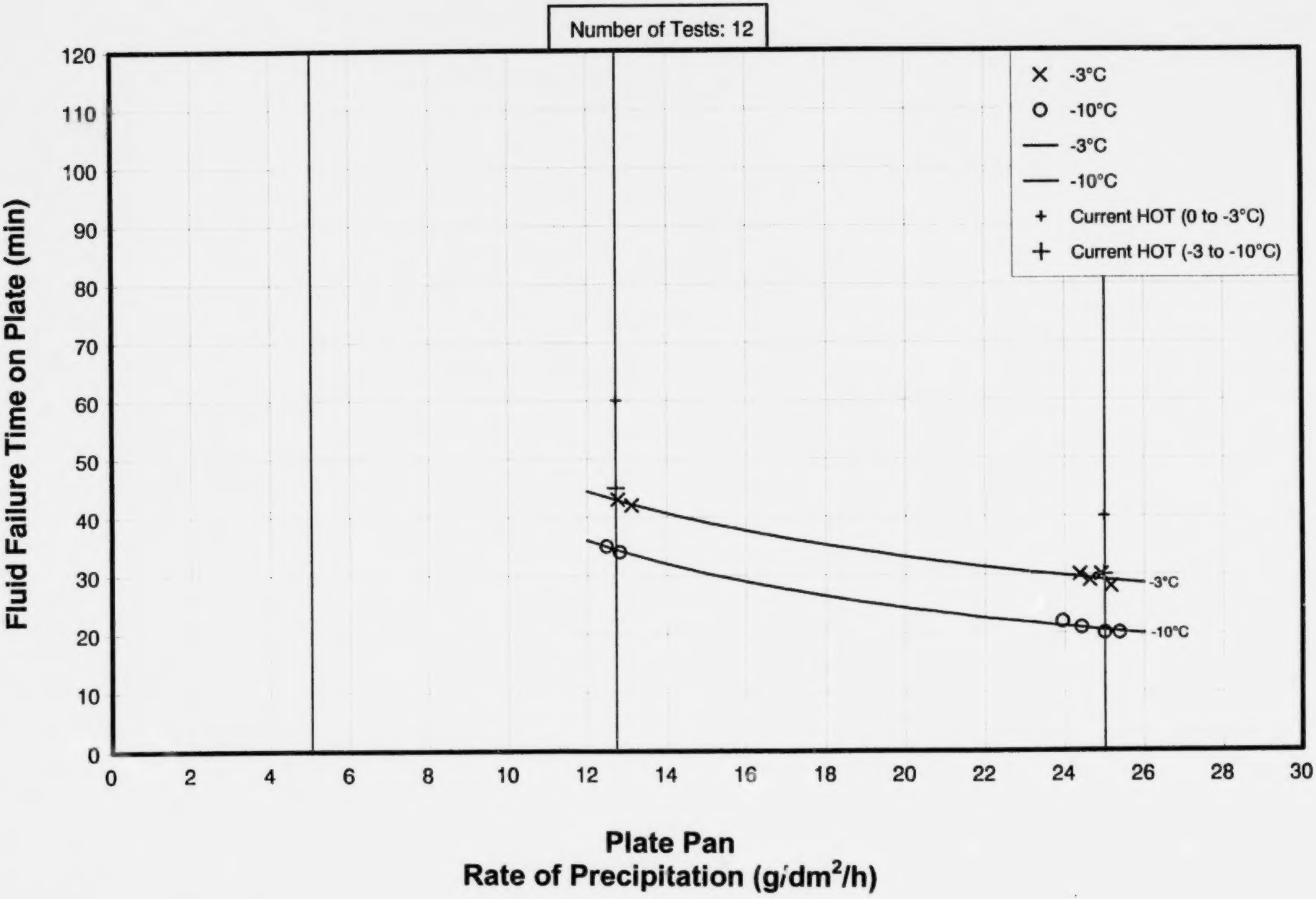
EFFECT OF TEMPERATURE AND RATE OF PRECIPITATION ON ENDURANCE TIME

CLARIANT SAFEWING MPIV 1957 TYPE IV NEAT

SIMULATED LIGHT FREEZING RAIN

1998-99



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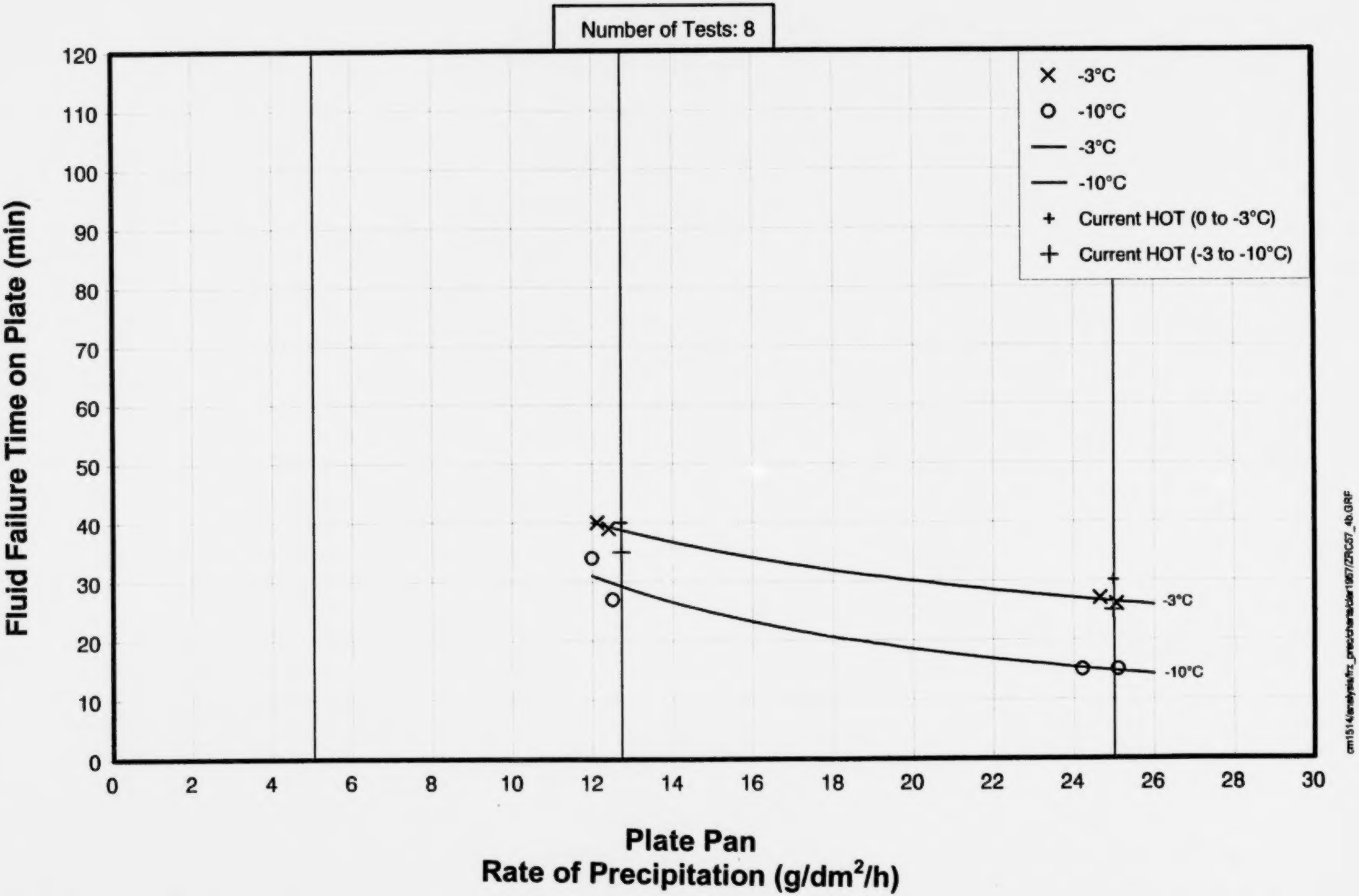
CLARIANT SAFEWING MPIV 1957 TYPE IV 75/25

SIMULATED LIGHT FREEZING RAIN

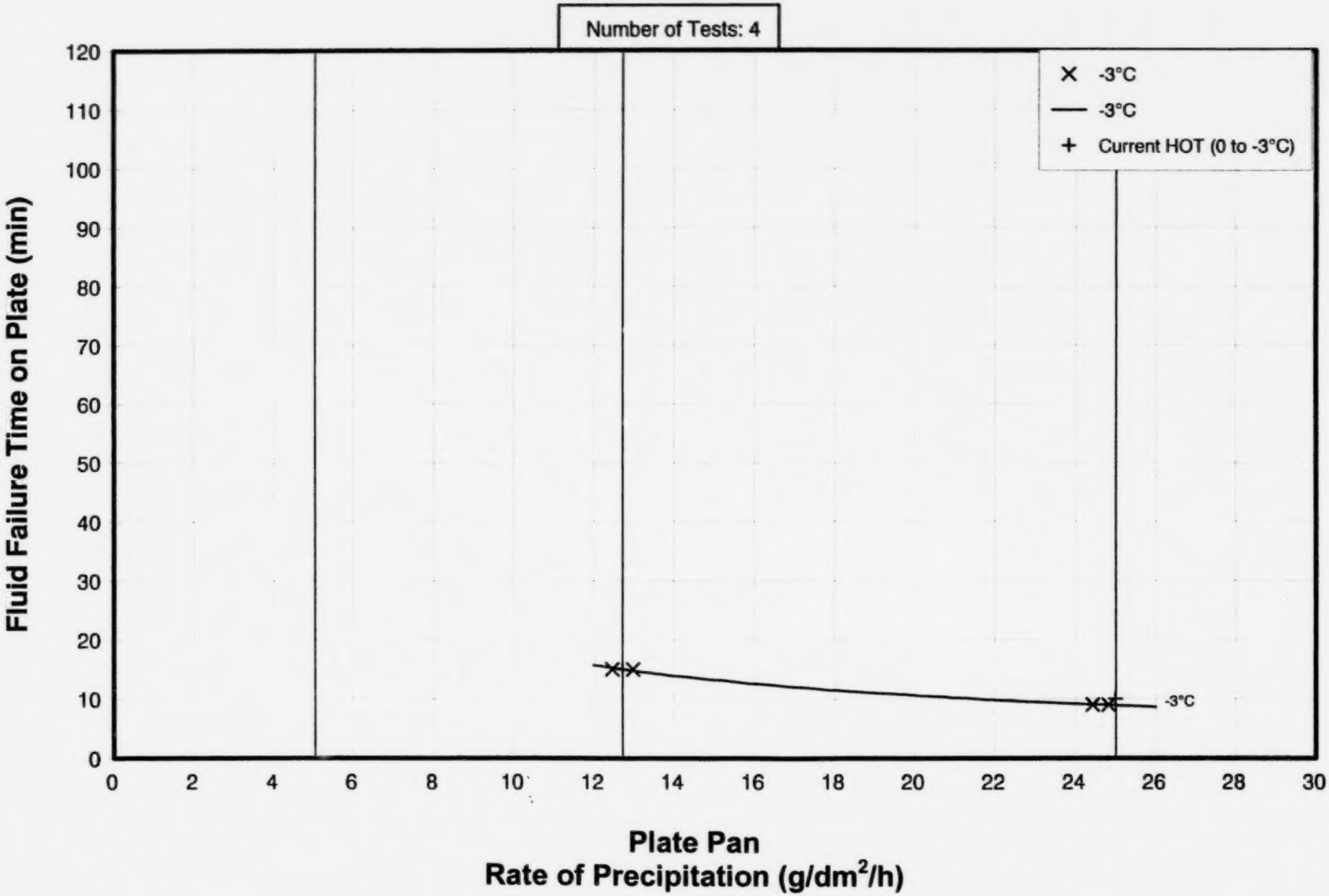
1998-99



CLARIANT SAFEWING MPIV 1957 TYPE IV 50/50

SIMULATED LIGHT FREEZING RAIN

1998-99



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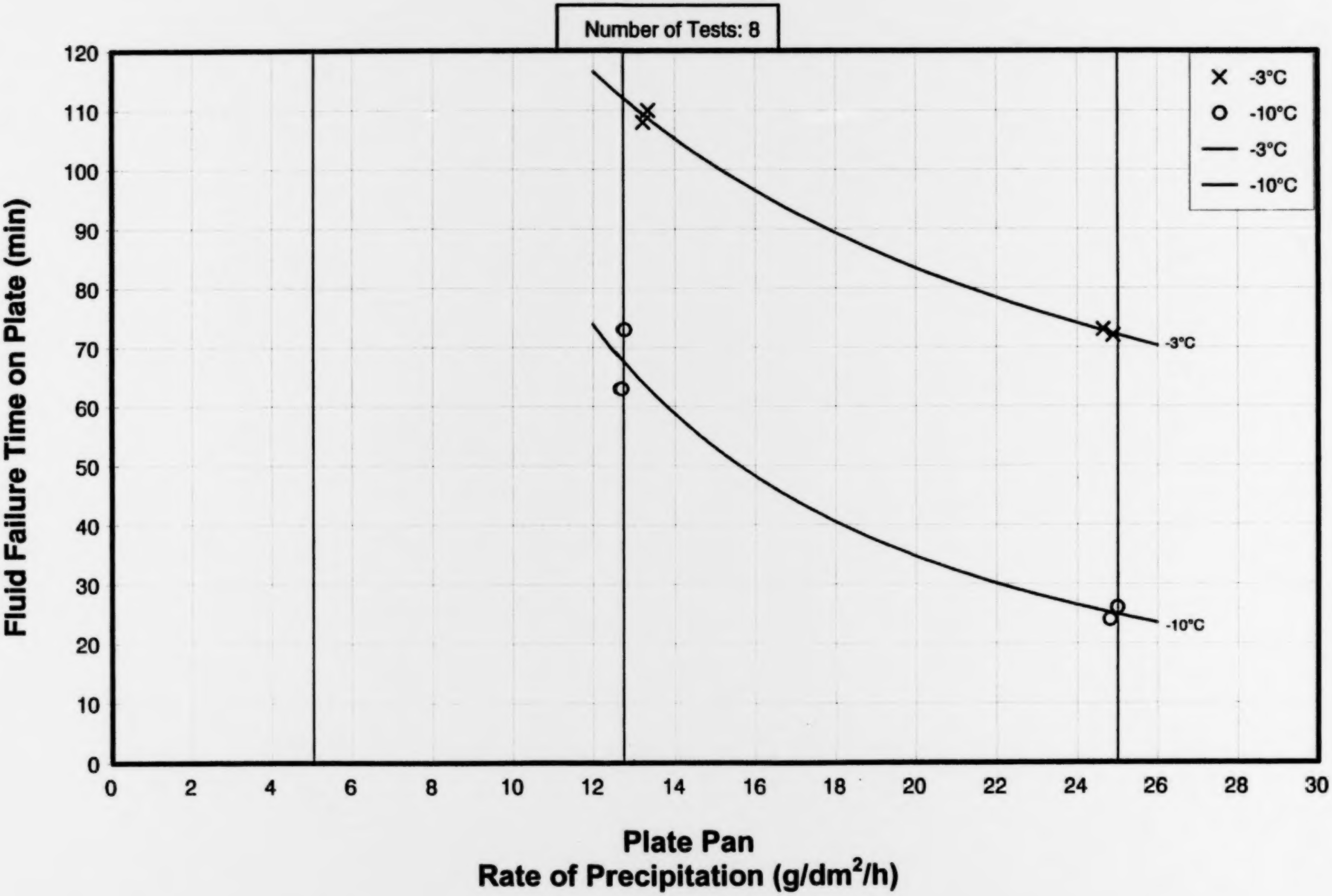
FLUID X

SIMULATED LIGHT FREEZING RAIN

1998-99



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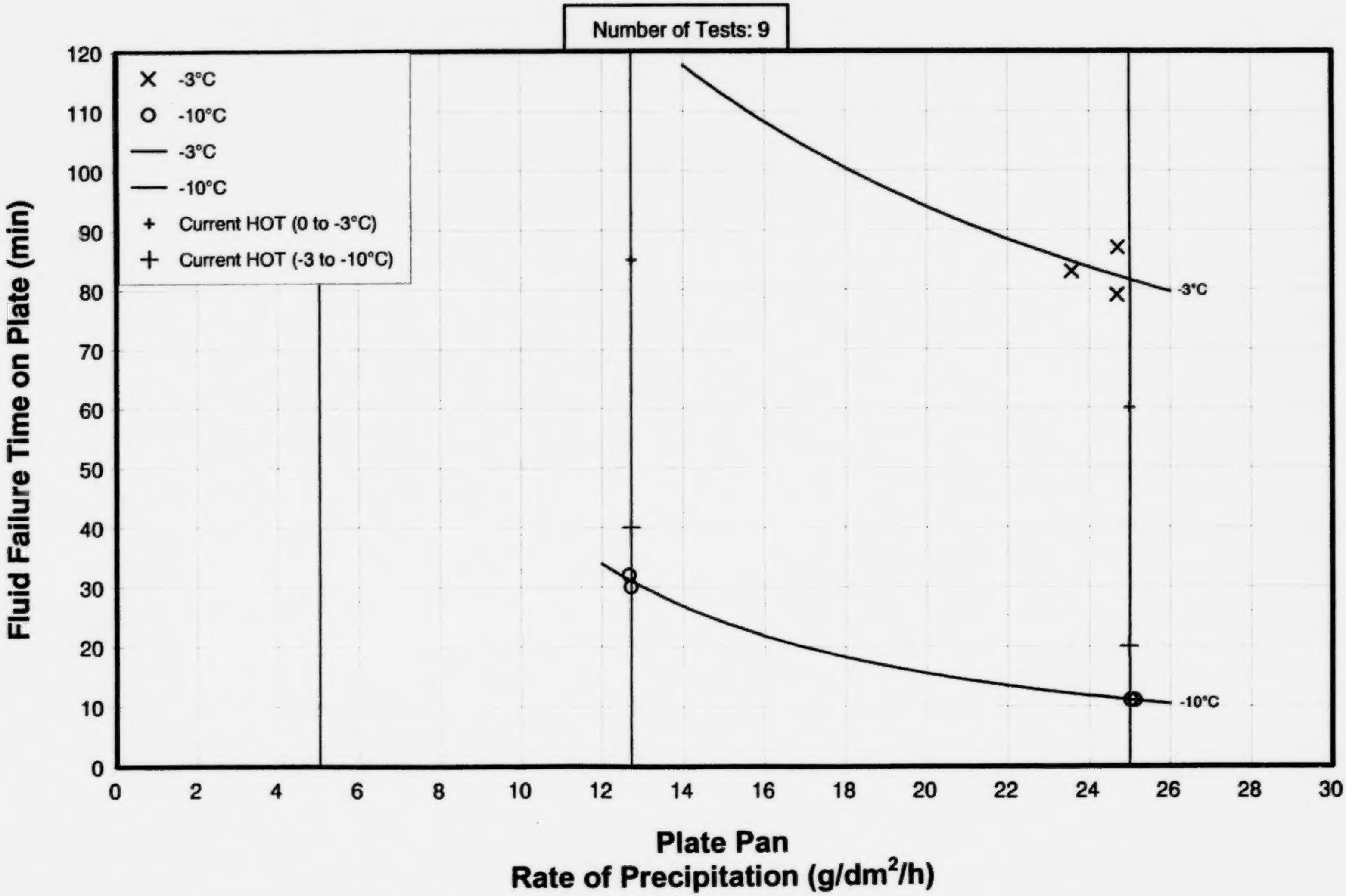
KILFROST ABC-S TYPE IV NEAT

SIMULATED LIGHT FREEZING RAIN

1998-99



KILFROST ABC-S TYPE IV 75/25

SIMULATED LIGHT FREEZING RAIN

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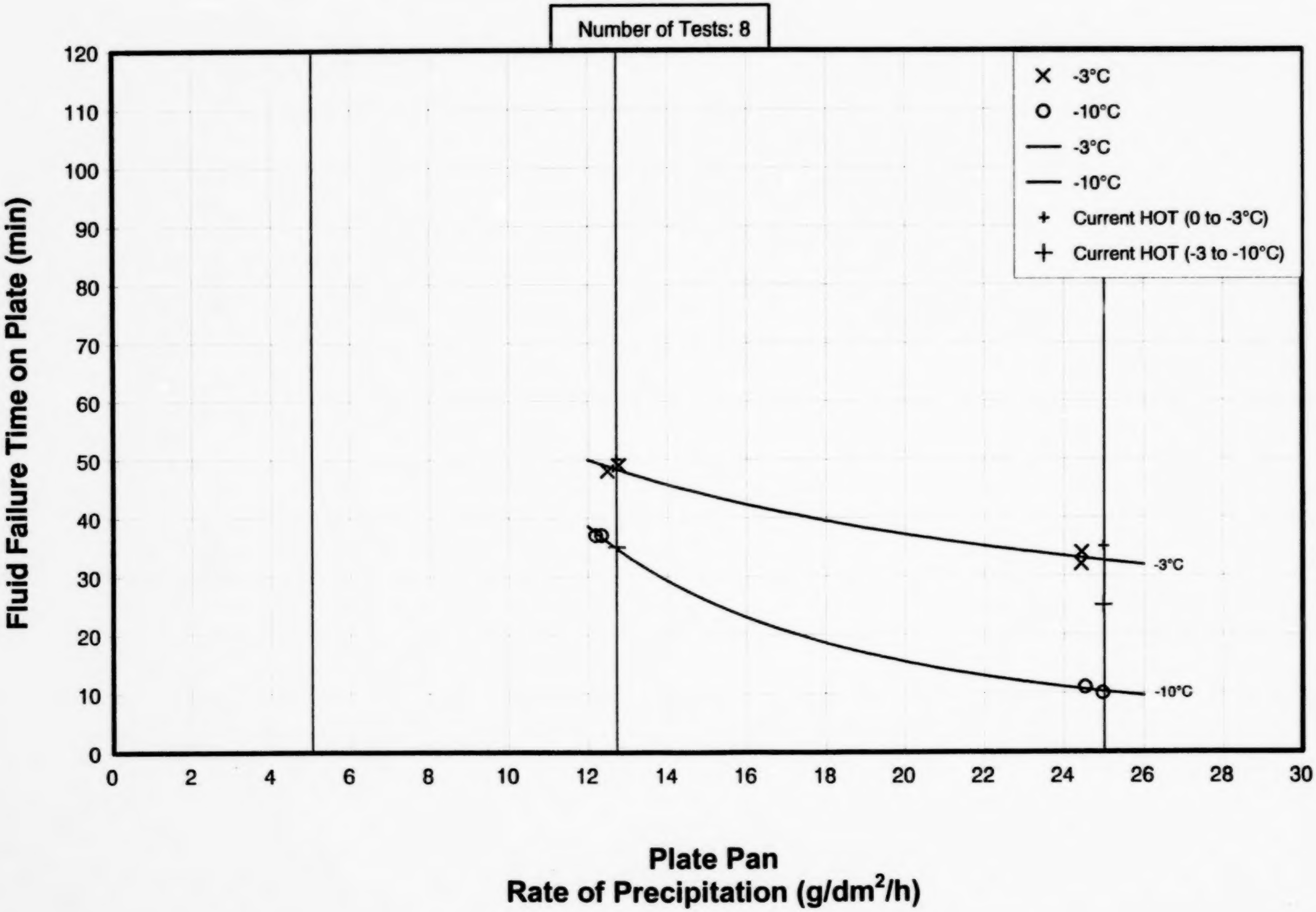

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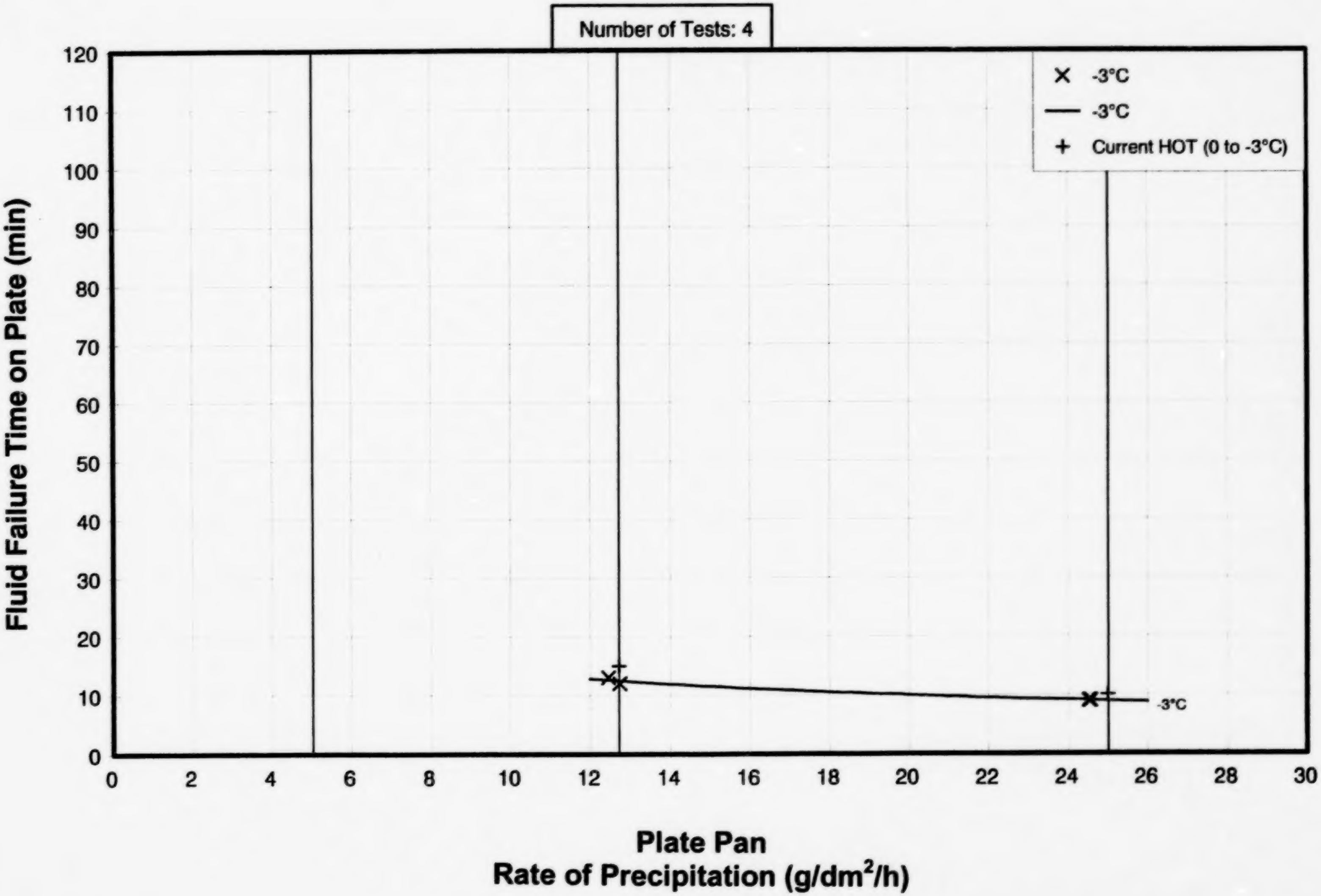
EFFECT OF TEMPERATURE AND RATE OF PRECIPITATION ON ENDURANCE TIME

KILFROST ABC-S TYPE IV 50/50

SIMULATED LIGHT FREEZING RAIN

1998-99



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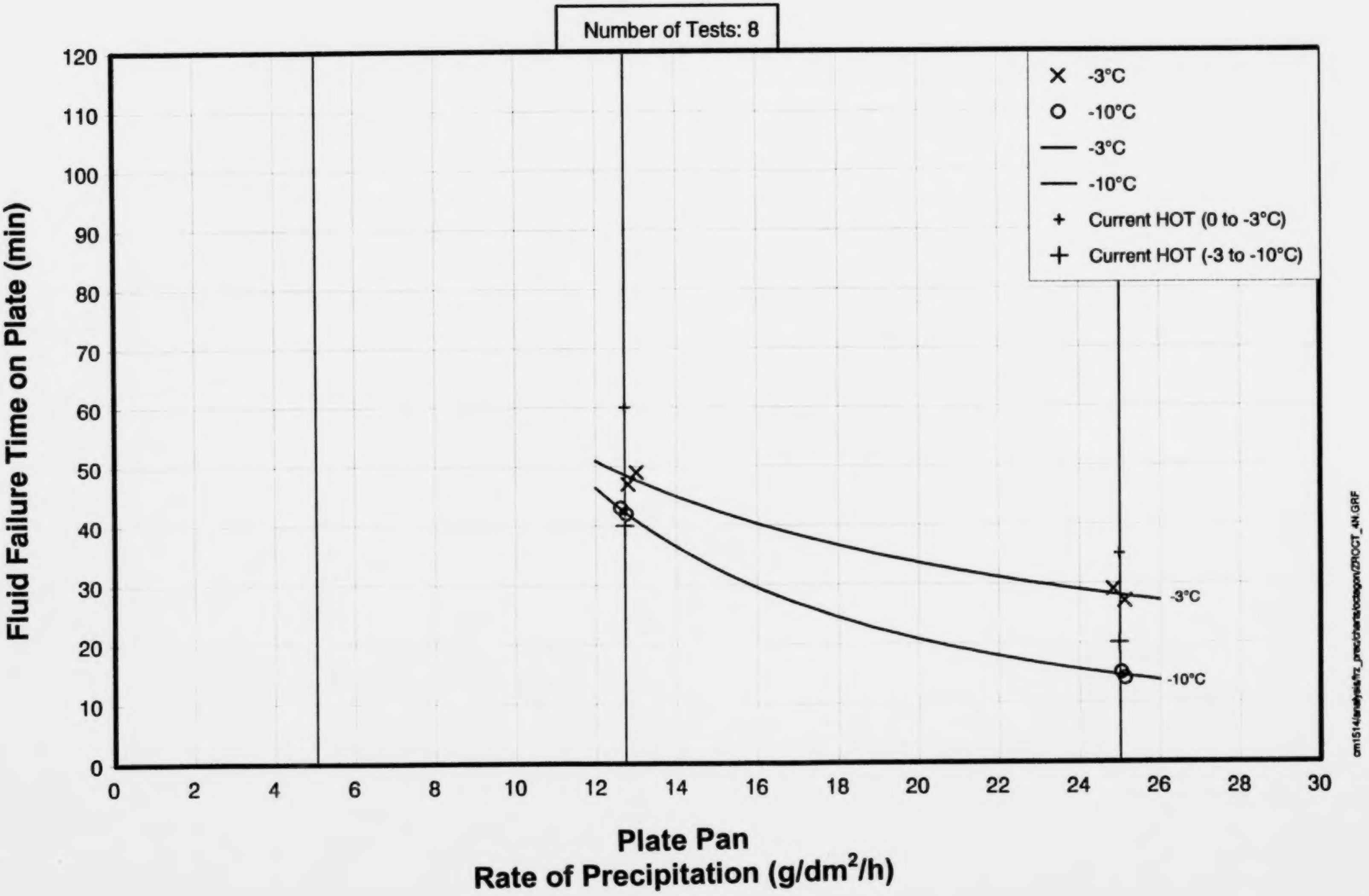
OCTAGON MAXFLIGHT TYPE IV NEAT

SIMULATED LIGHT FREEZING RAIN

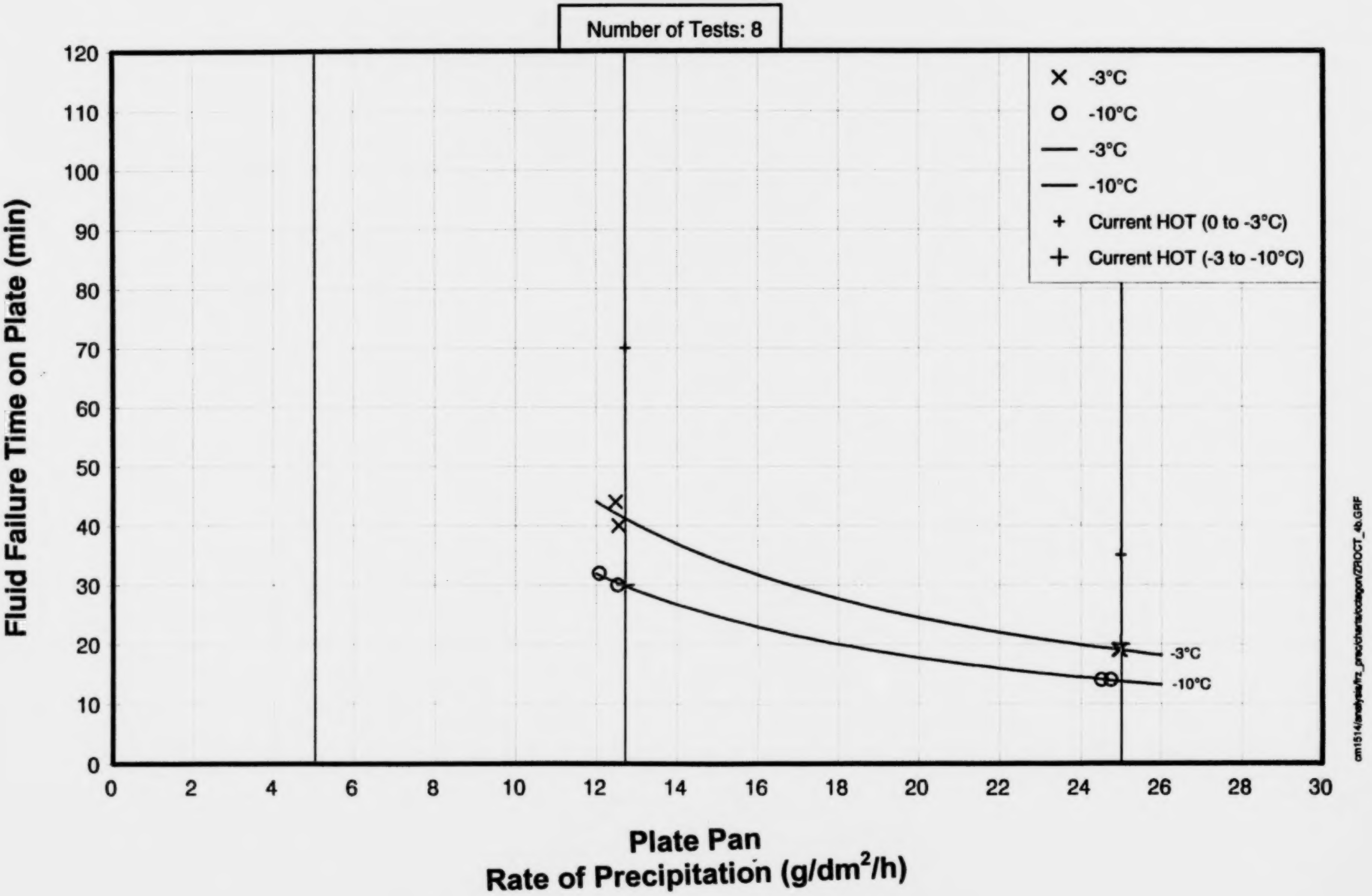
1998-99



OCTAGON MAXFLIGHT TYPE IV 75/25

SIMULATED LIGHT FREEZING RAIN

1998-99

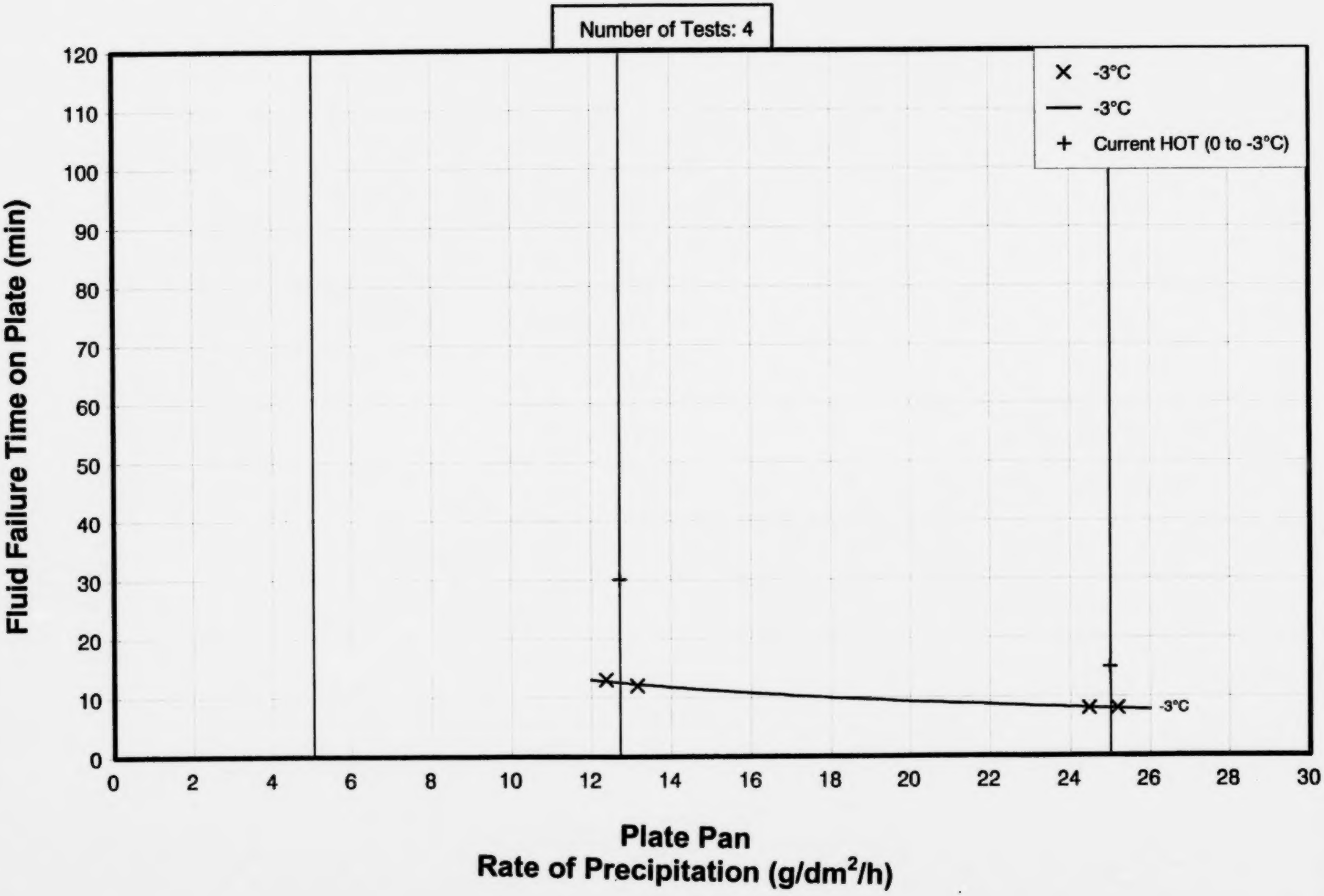


EFFECT OF TEMPERATURE AND RATE OF PRECIPITATION ON ENDURANCE TIME

OCTAGON MAXFLIGHT TYPE IV 50/50

SIMULATED LIGHT FREEZING RAIN

1998-99



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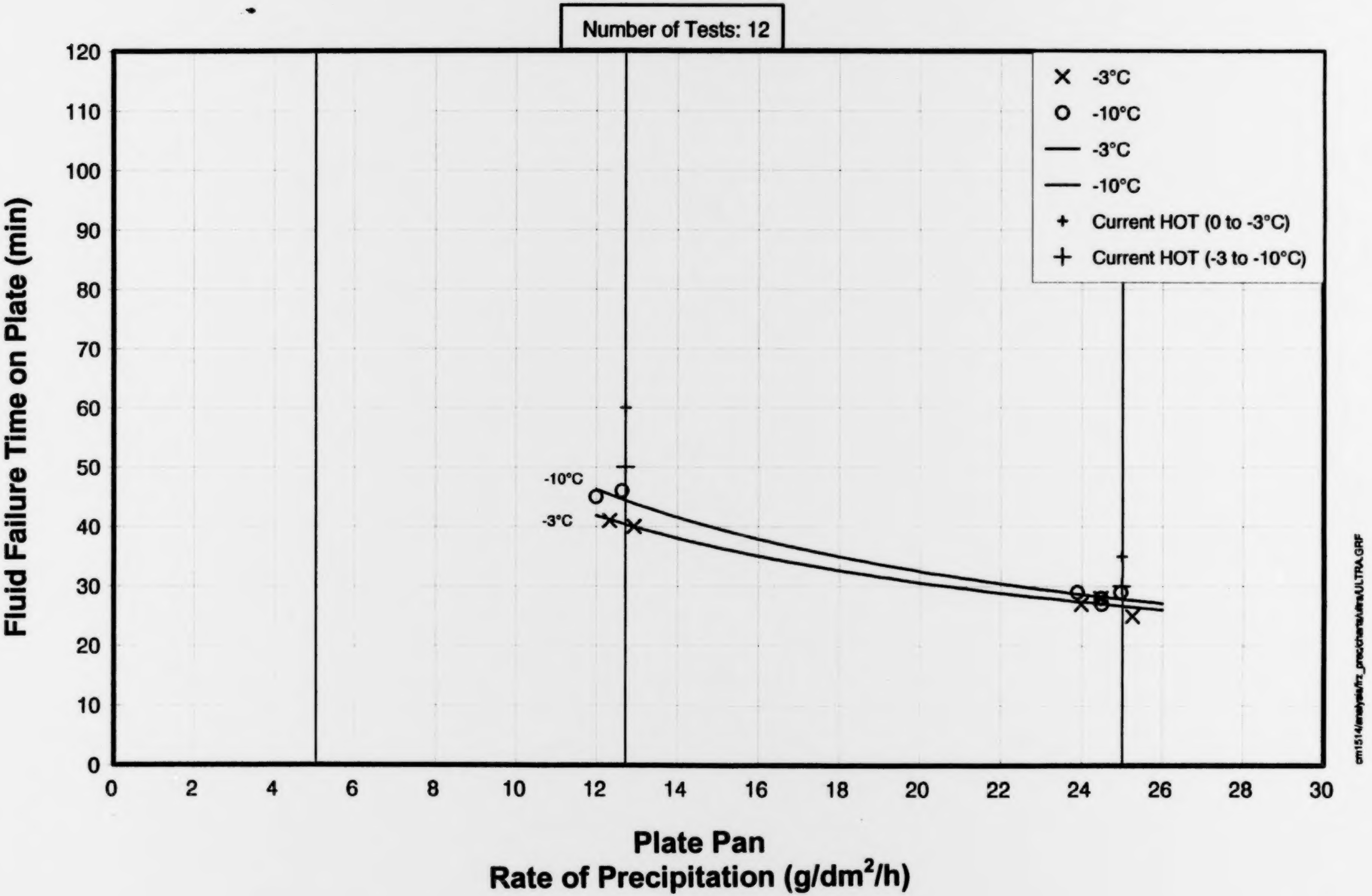
UCAR ULTRA+ TYPE IV NEAT

SIMULATED LIGHT FREEZING RAIN

1998-99

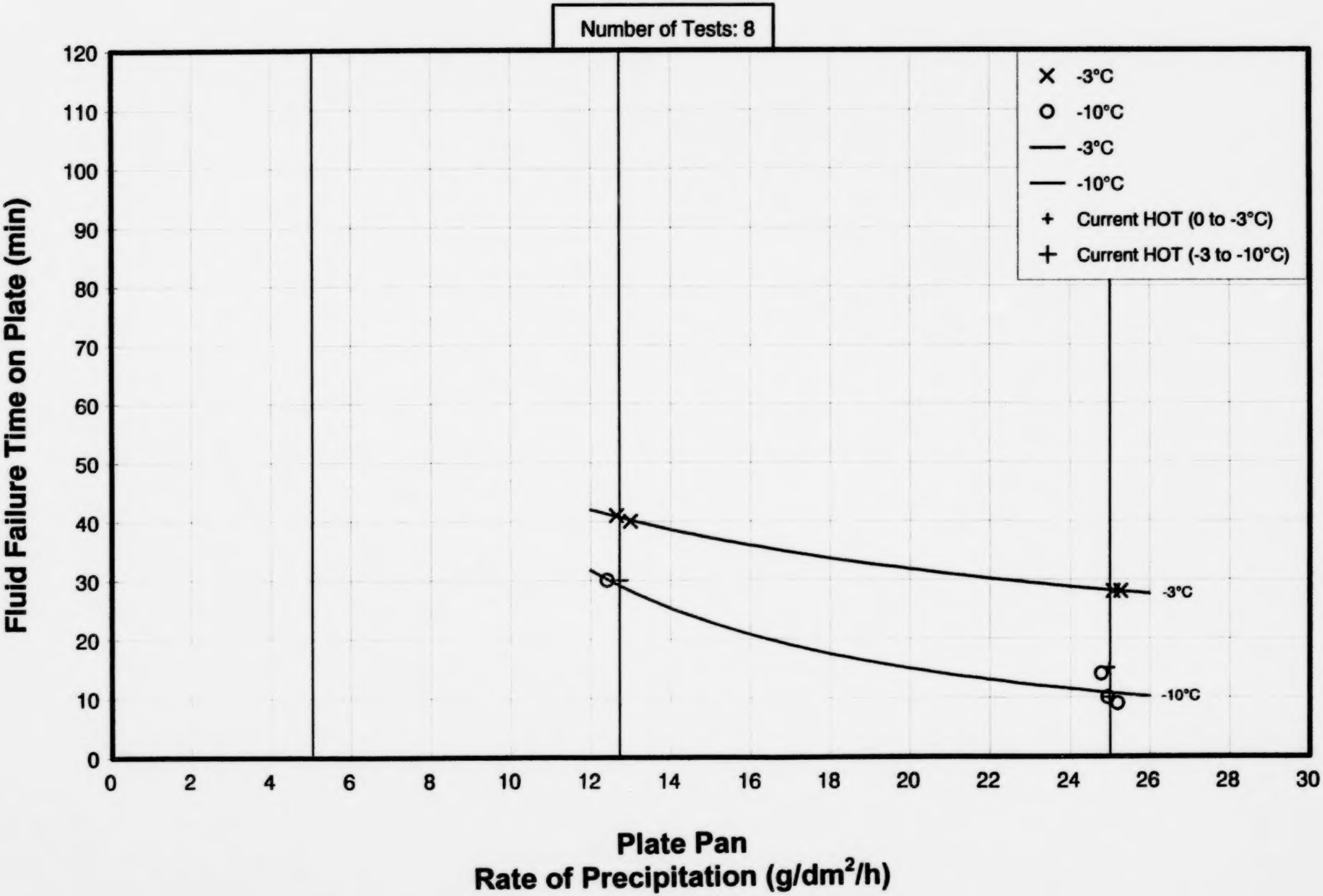


EFFECT OF TEMPERATURE AND RATE OF PRECIPITATION ON ENDURANCE TIME

KILFROST ABC-II PLUS NEAT

SIMULATED LIGHT FREEZING RAIN

1998-99



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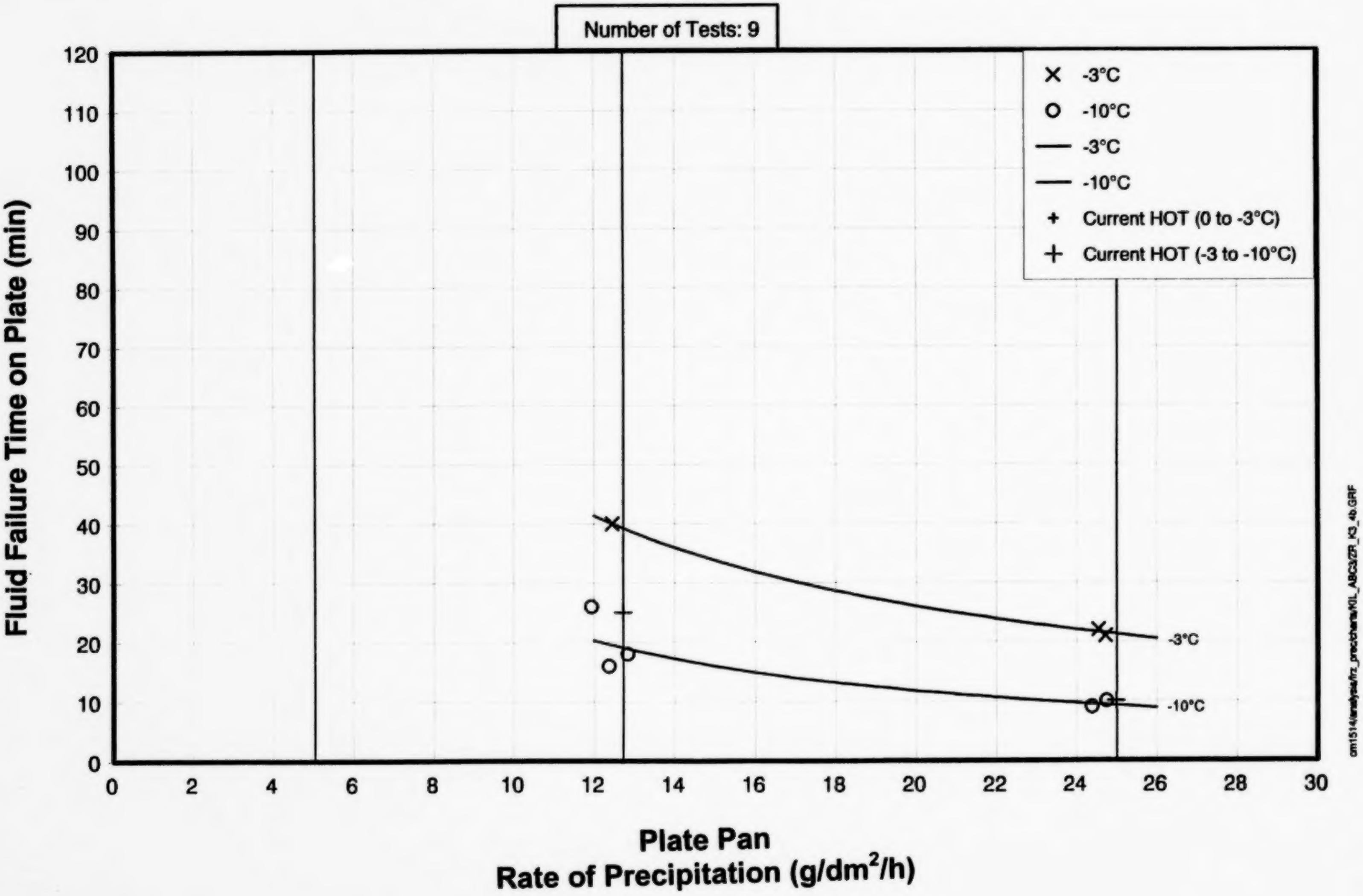
KILFROST ABC-II PLUS 75/25

SIMULATED LIGHT FREEZING RAIN

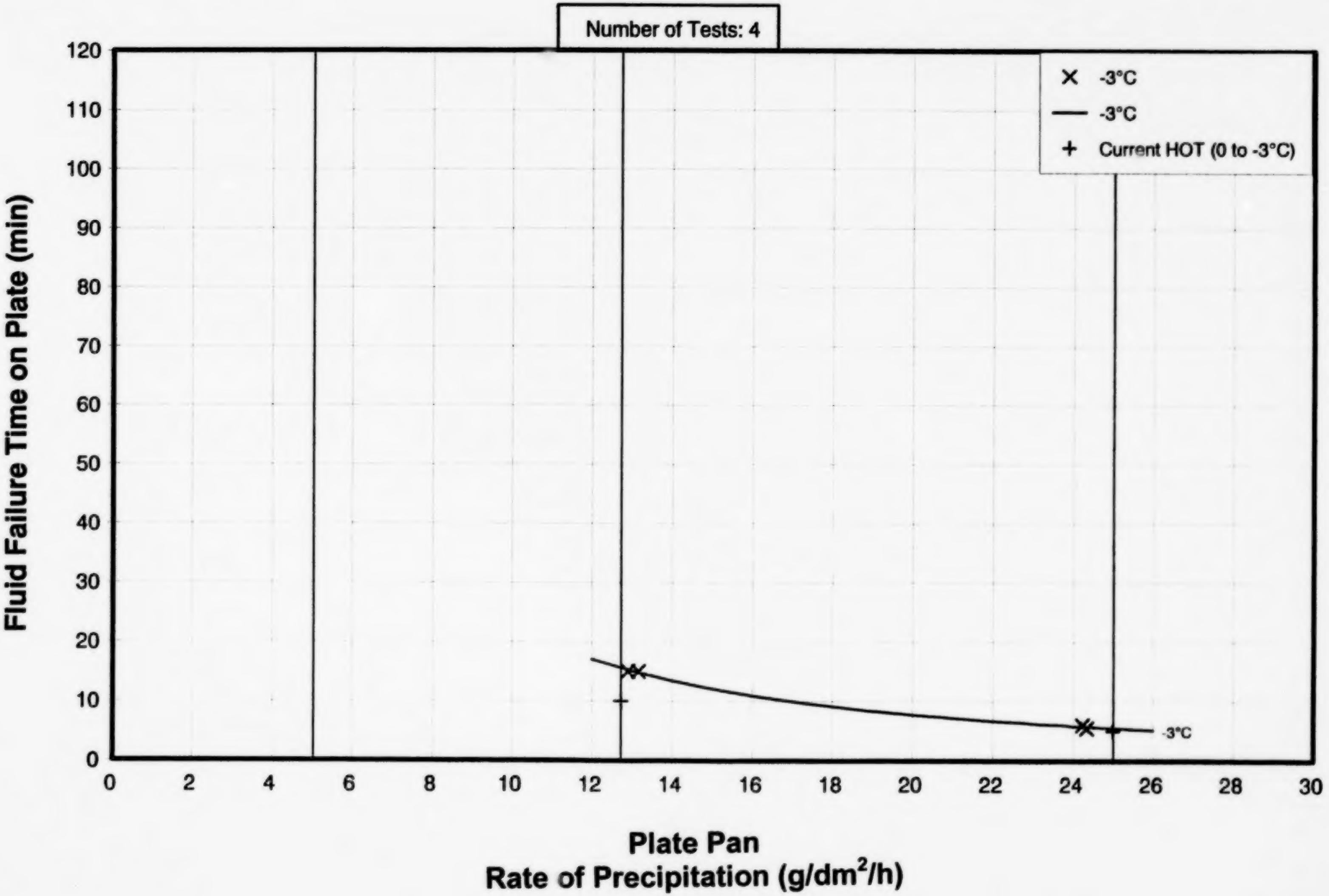
1998-99



KILFROST ABC-II PLUS 50/50

SIMULATED LIGHT FREEZING RAIN

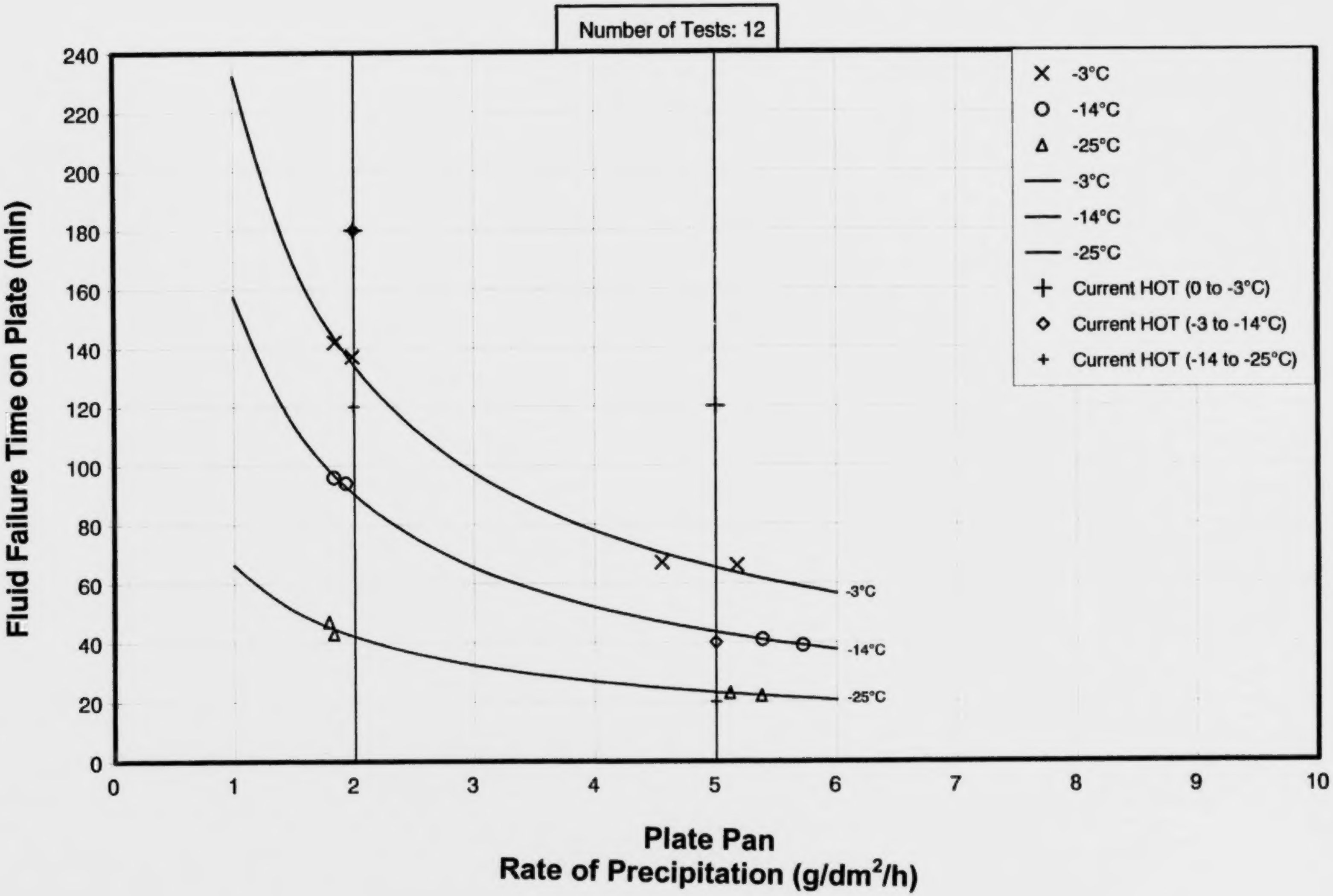
1998-99



CLARIANT SAFEWING MPIV 1957 TYPE IV NEAT

SIMULATED FREEZING FOG

1998-99



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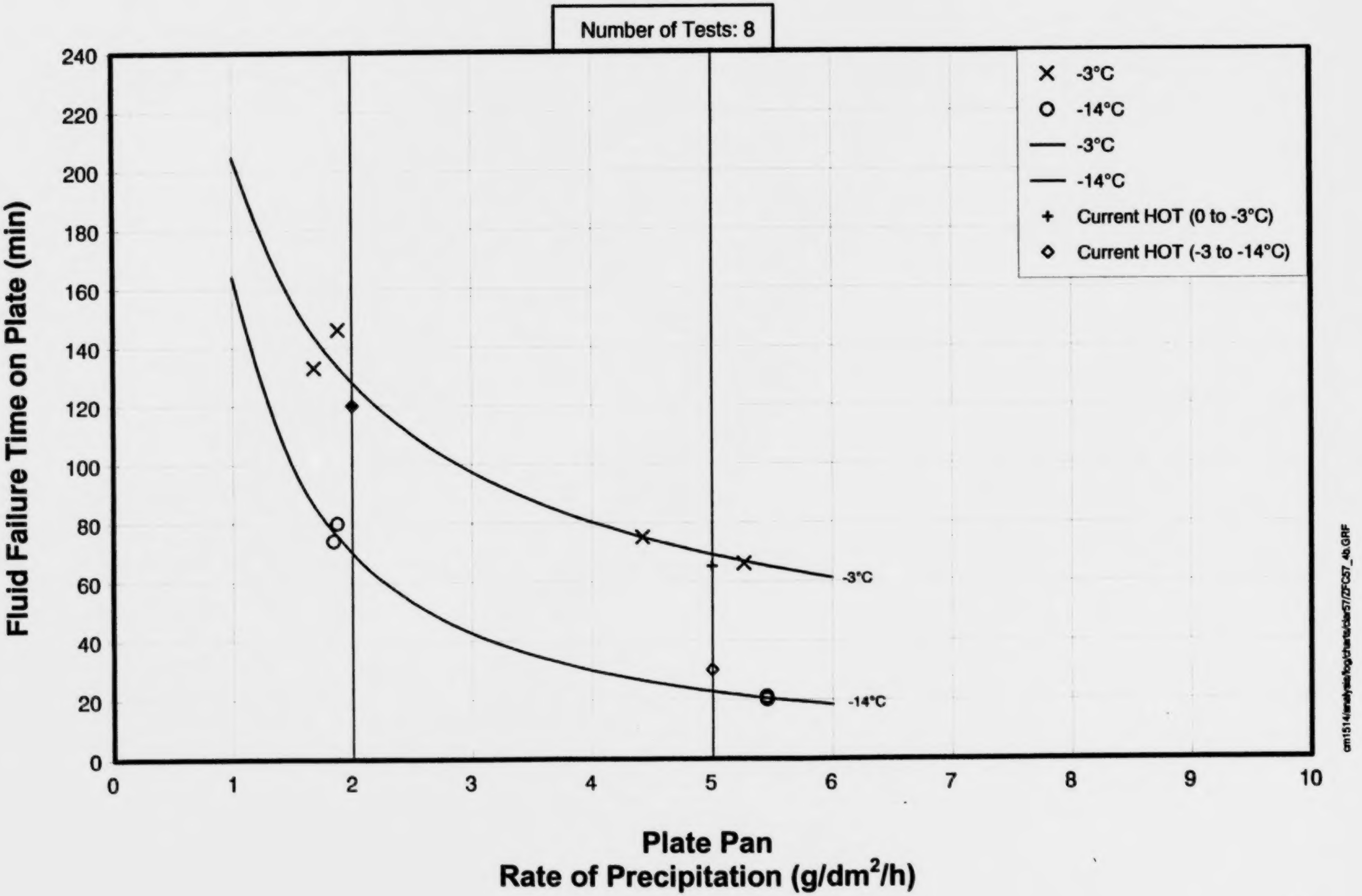
EFFECT OF TEMPERATURE AND RATE OF PRECIPITATION ON ENDURANCE TIME

CLARIANT SAFEWING MPIV 1957 TYPE IV 75/25

SIMULATED FREEZING FOG

1998-99

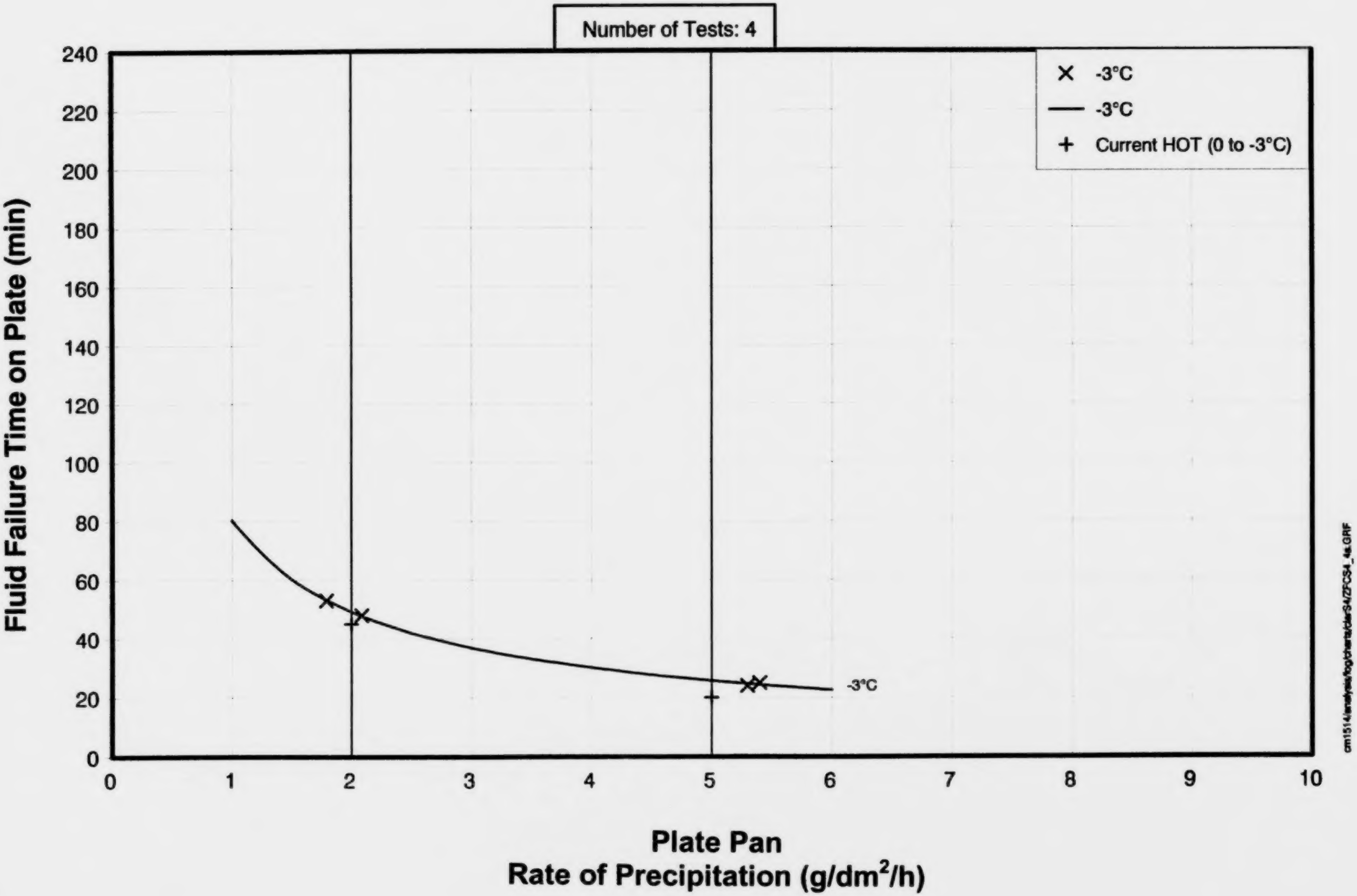


EFFECT OF TEMPERATURE AND RATE OF PRECIPITATION ON ENDURANCE TIME

CLARIANT SAFEWING MPIV 1957 TYPE IV 50/50

SIMULATED FREEZING FOG

1998-99

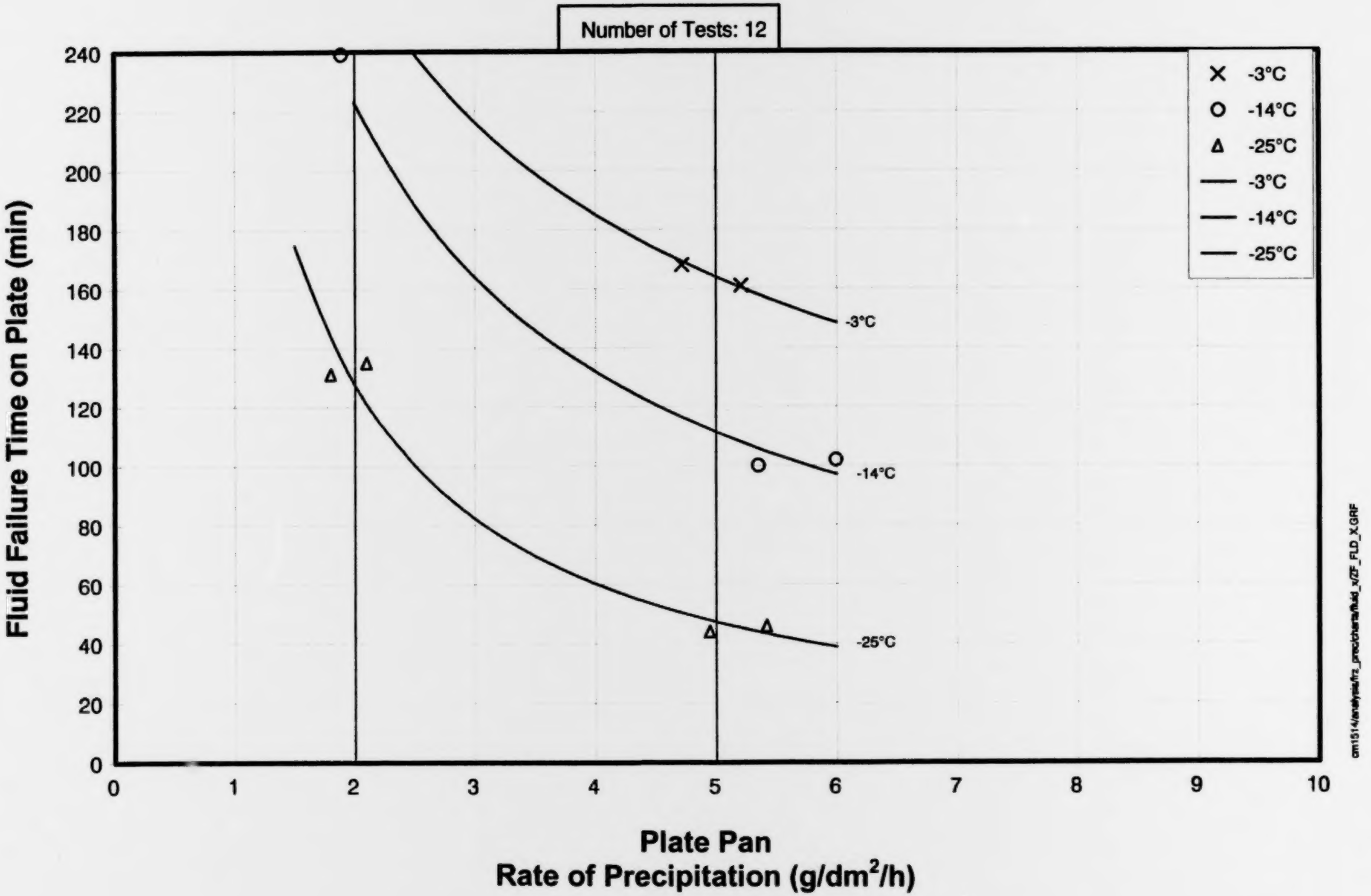


EFFECT OF TEMPERATURE AND RATE OF PRECIPITATION ON ENDURANCE TIME

FLUID X

SIMULATED FREEZING FOG

1998-99

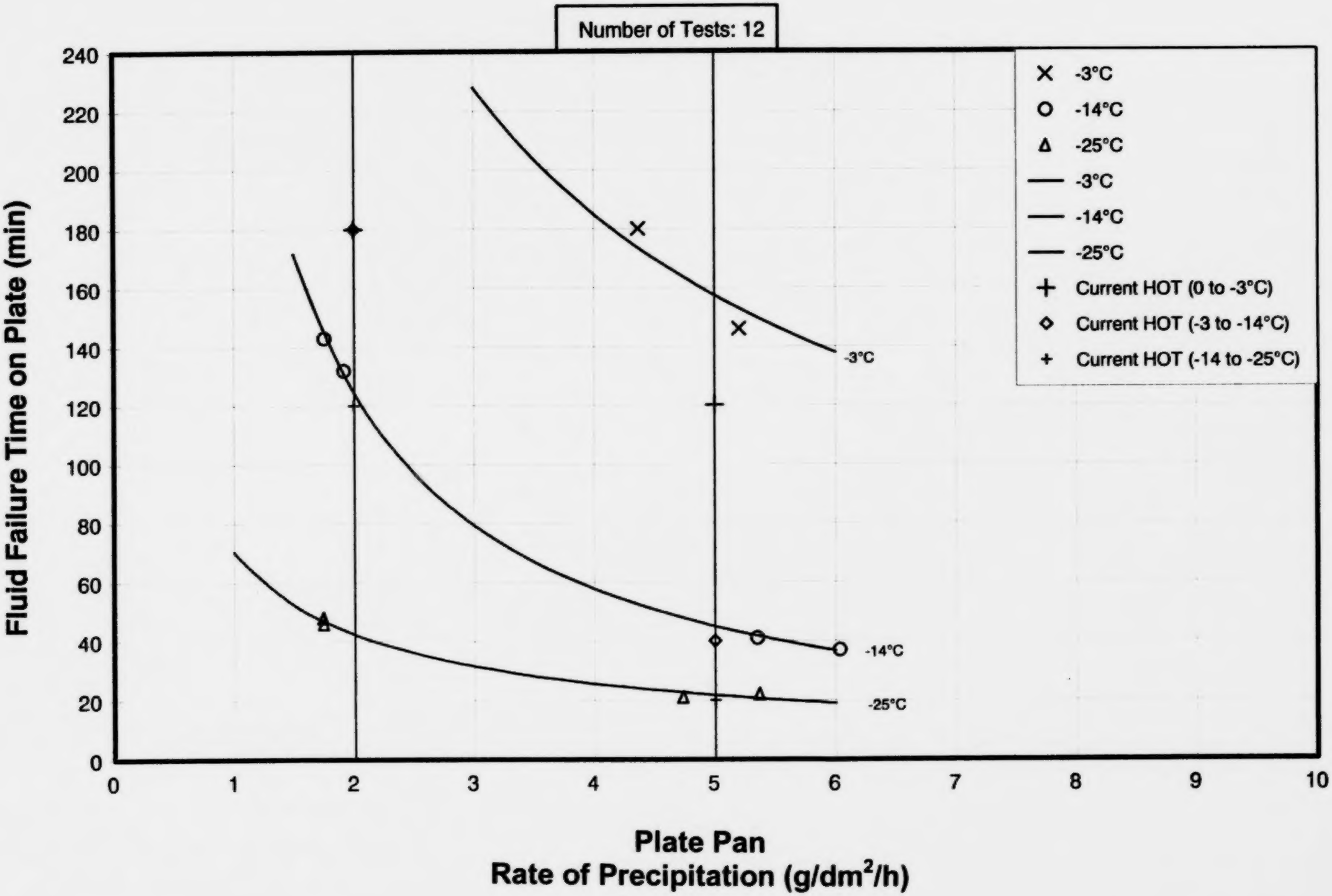


EFFECT OF TEMPERATURE AND RATE OF PRECIPITATION ON ENDURANCE TIME

KILFROST ABC-S TYPE IV NEAT

SIMULATED FREEZING FOG

1998-99



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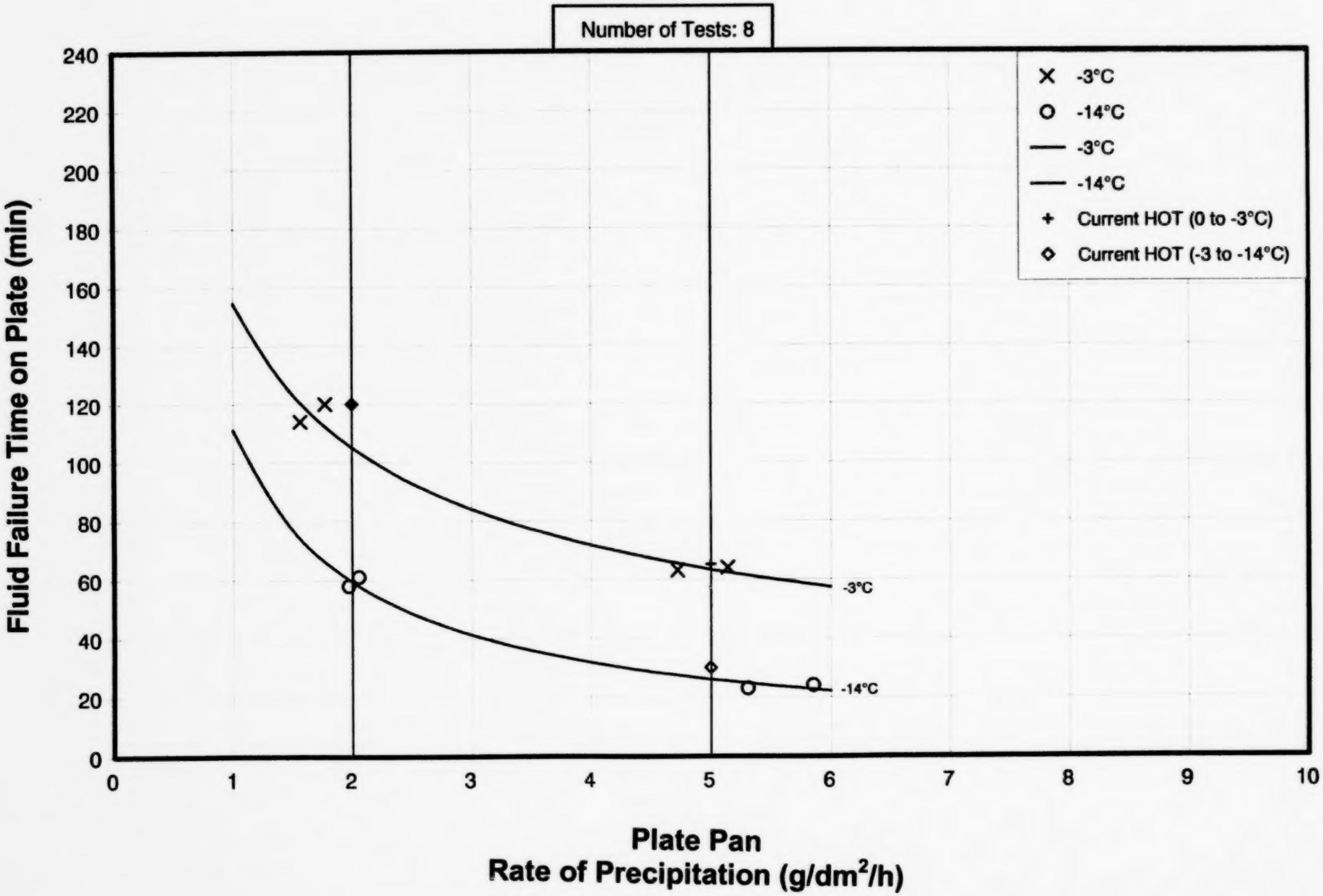
KILFROST ABC-S TYPE IV 75/25

SIMULATED FREEZING FOG

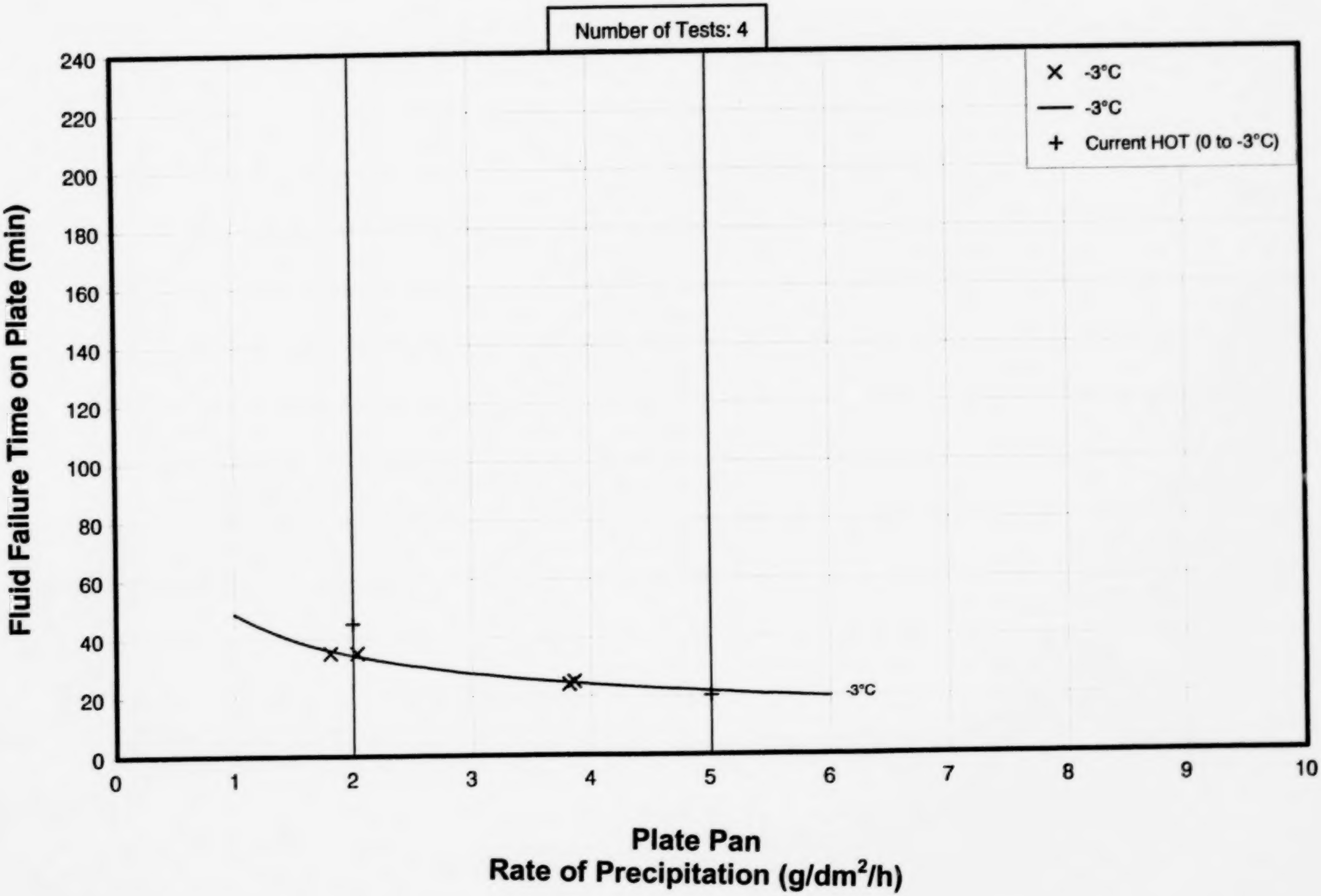
1998-99



KILFROST ABC-S TYPE IV 50/50

SIMULATED FREEZING FOG

1998-99



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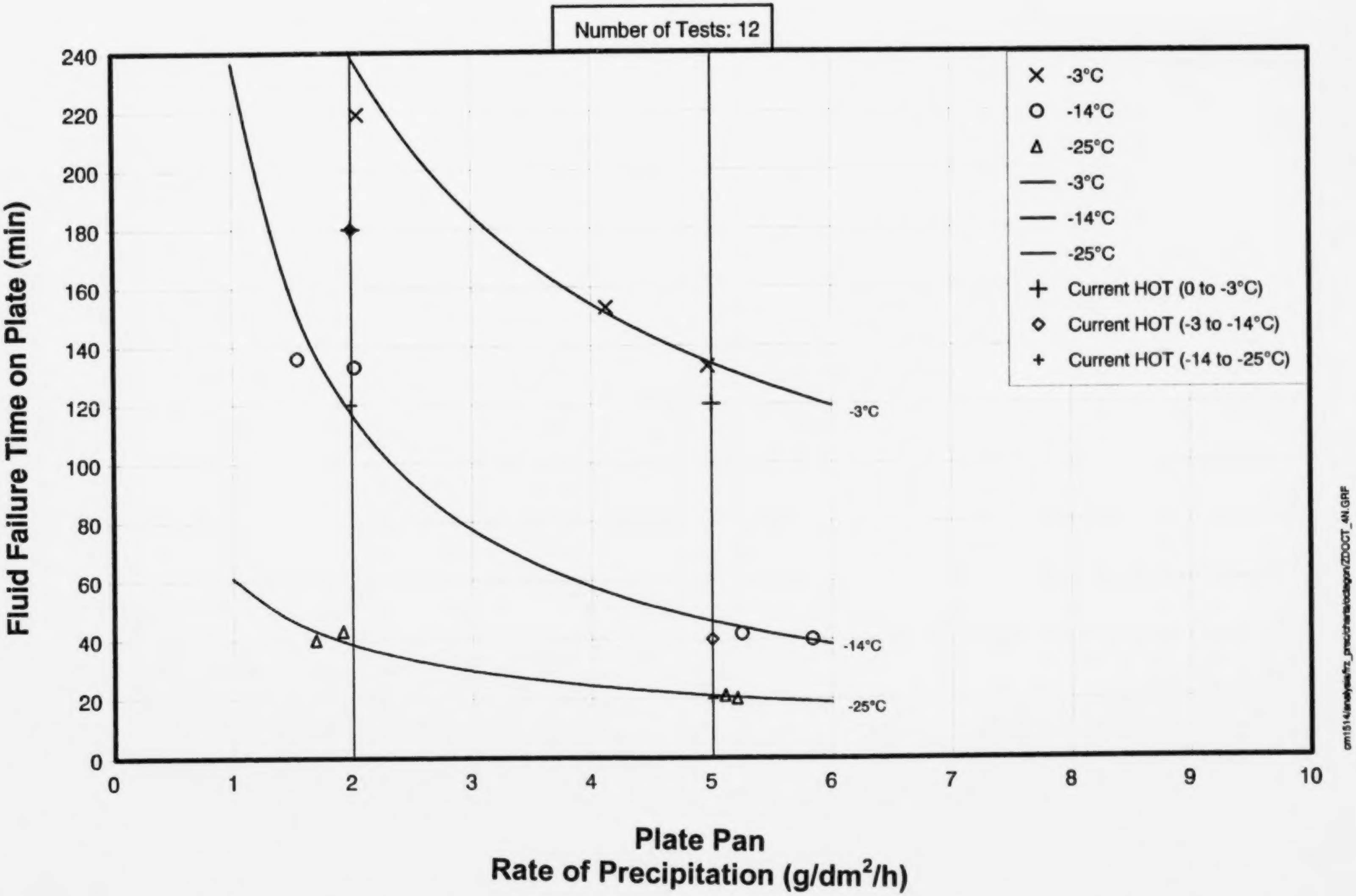
EFFECT OF TEMPERATURE AND RATE OF PRECIPITATION ON ENDURANCE TIME

OCTAGON MAXFLIGHT TYPE IV NEAT

SIMULATED FREEZING FOG

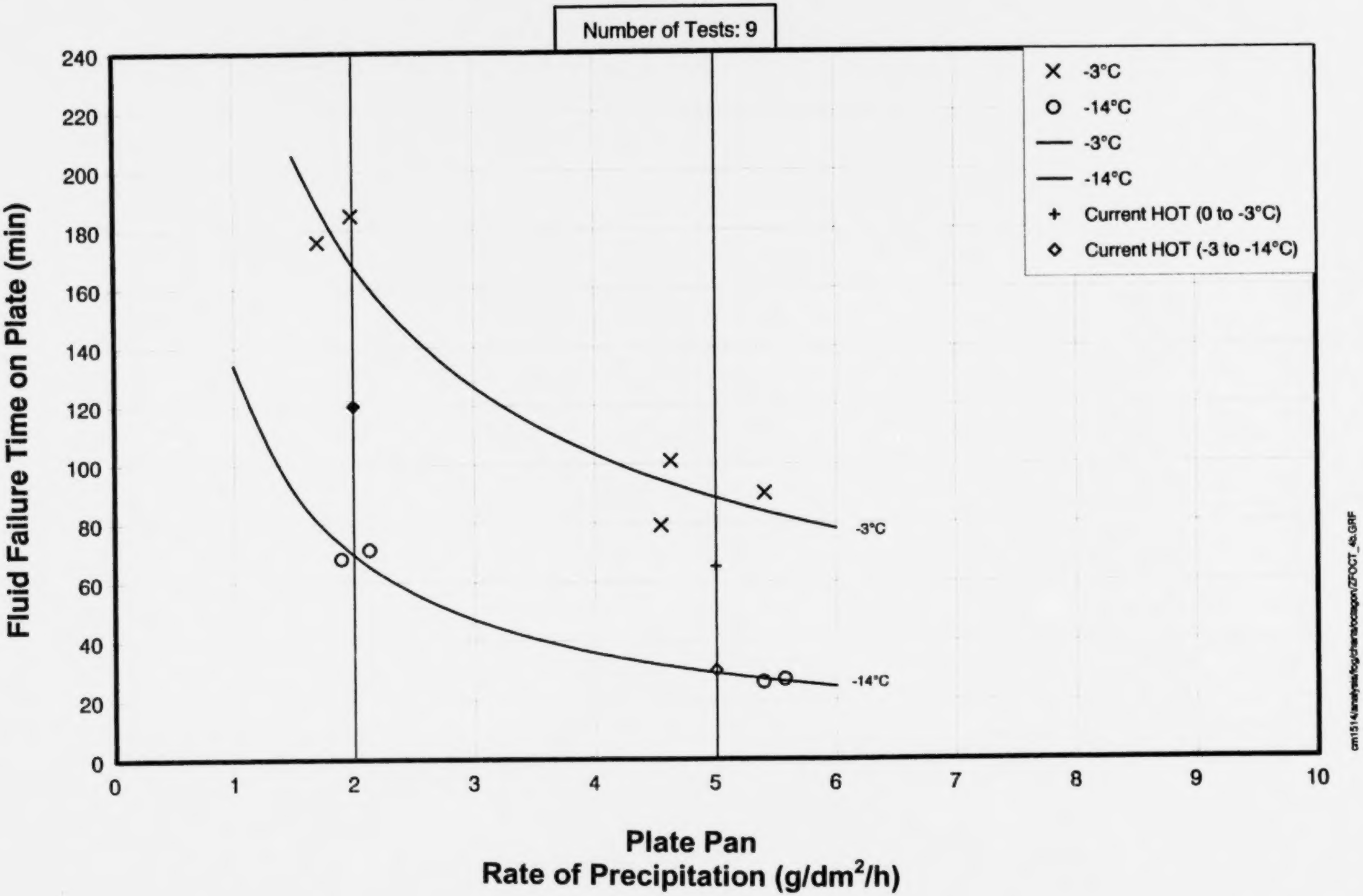
1998-99



OCTAGON MAXFLIGHT TYPE IV 75/25

SIMULATED FREEZING FOG

1998-99

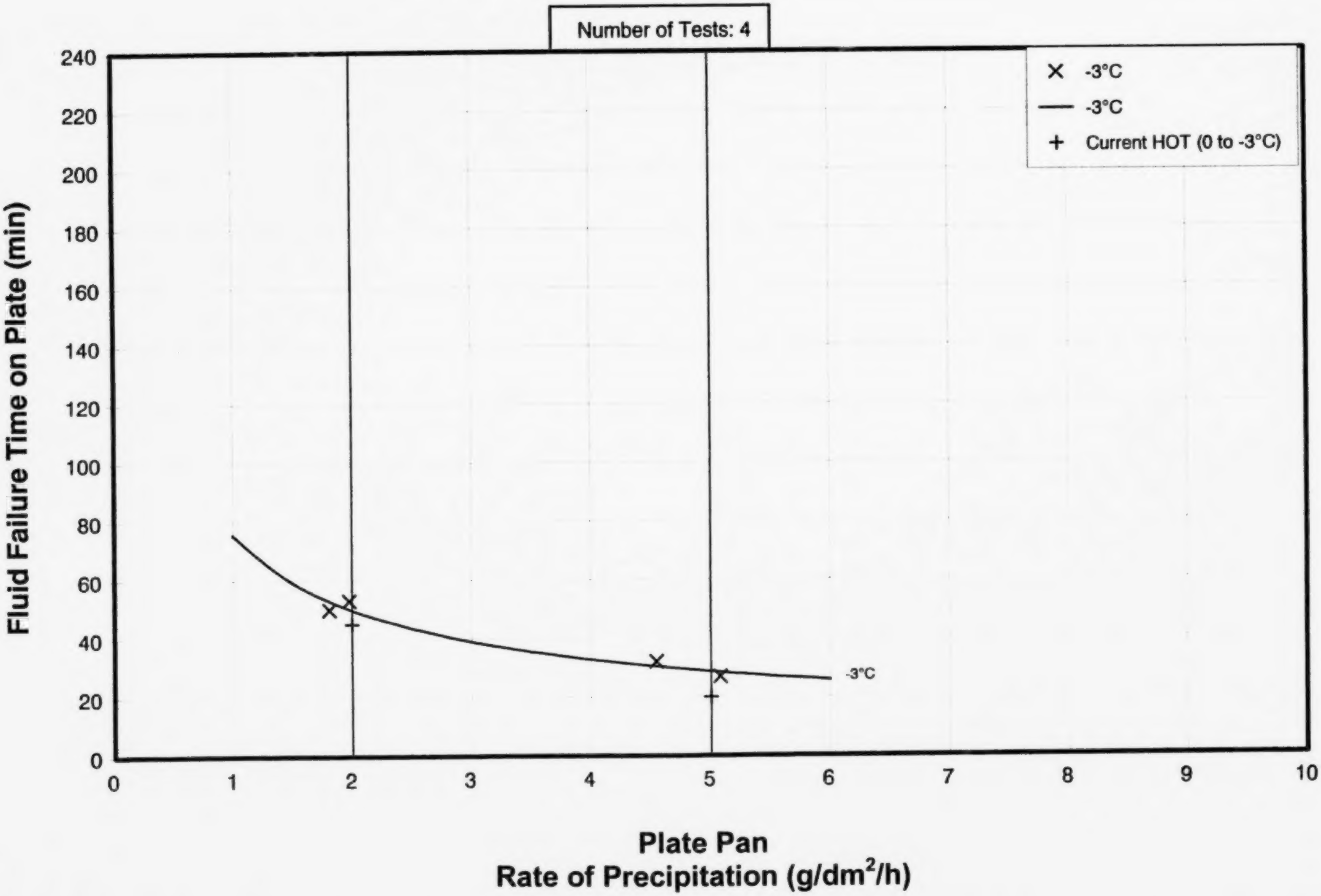


EFFECT OF TEMPERATURE AND RATE OF PRECIPITATION ON ENDURANCE TIME

OCTAGON MAXFLIGHT TYPE IV 50/50

SIMULATED FREEZING FOG

1998-99



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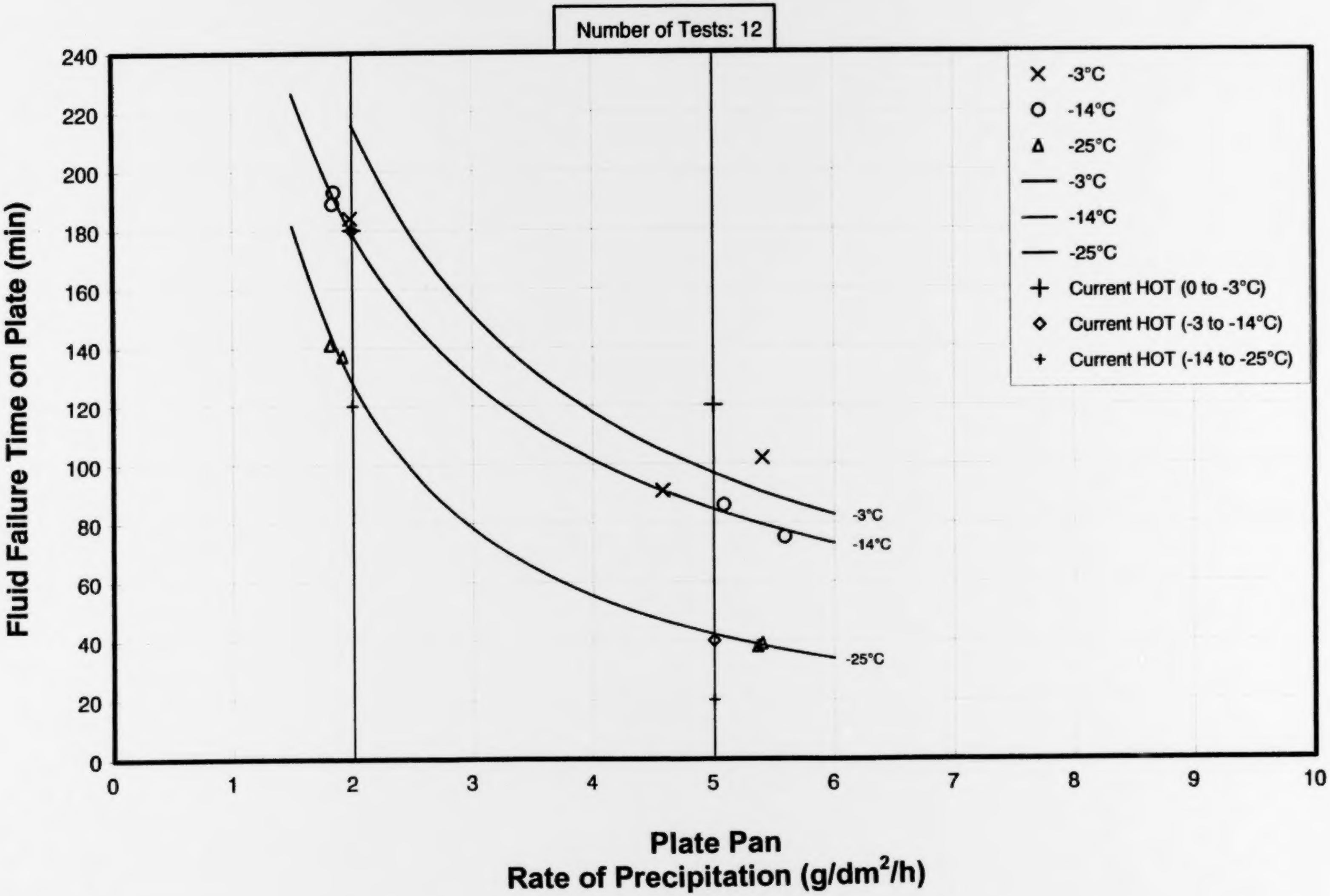
EFFECT OF TEMPERATURE AND RATE OF PRECIPITATION ON ENDURANCE TIME

UCAR ULTRA + TYPE IV NEAT

SIMULATED FREEZING FOG

1998-99



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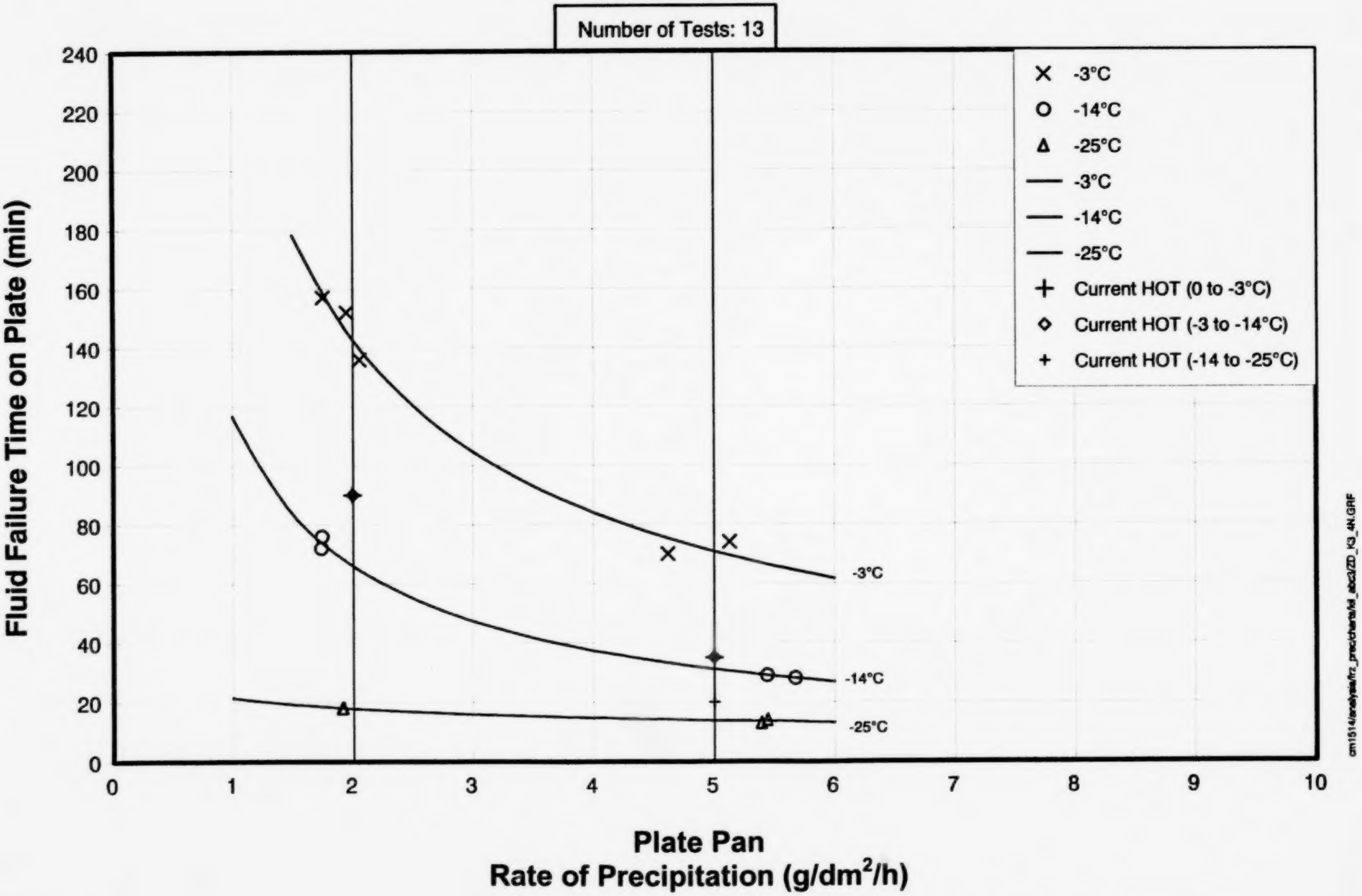
KILFROST ABC-II PLUS NEAT

SIMULATED FREEZING FOG

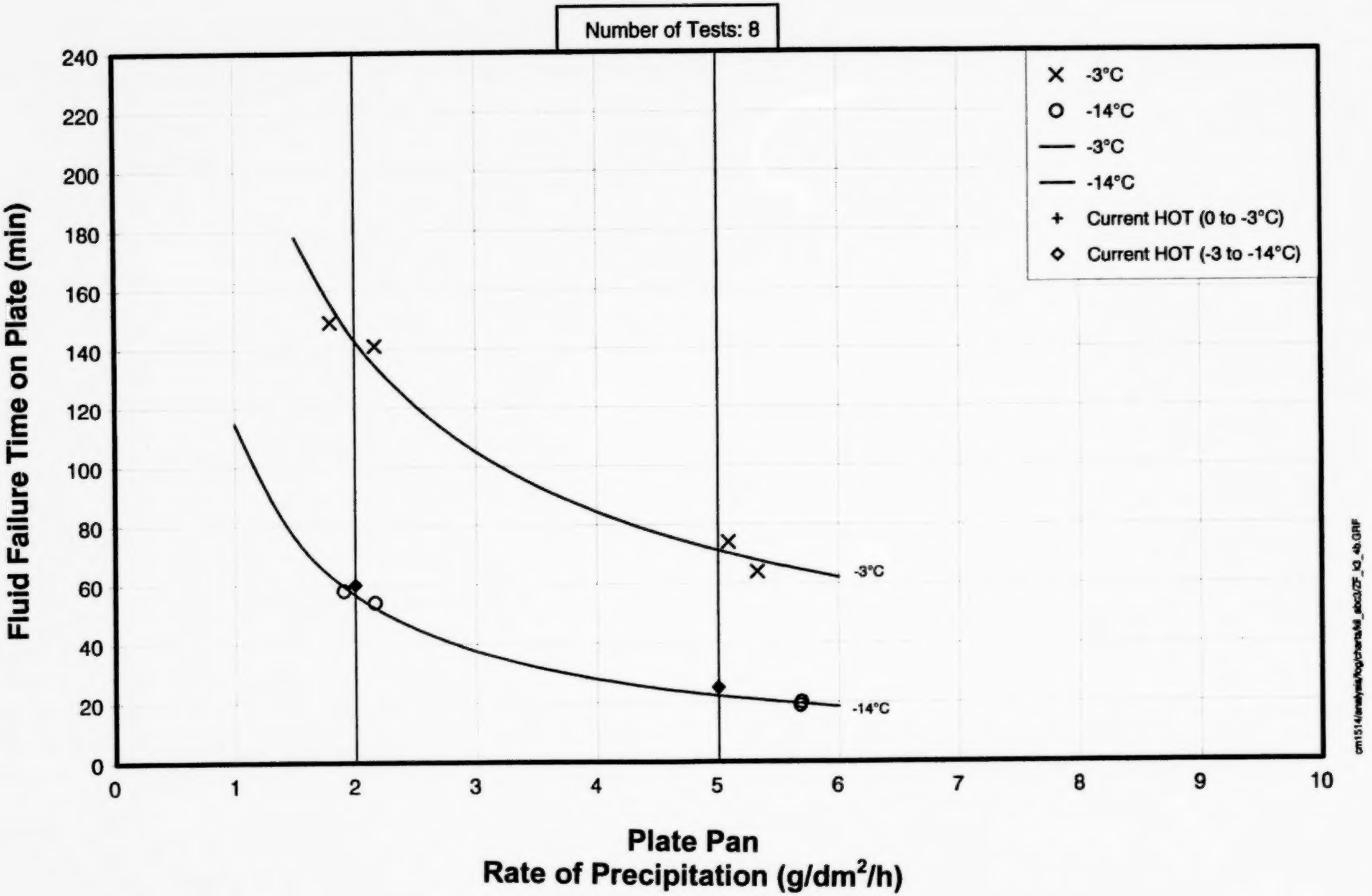
1998-99



KILFROST ABC-II PLUS 75/25

SIMULATED FREEZING FOG

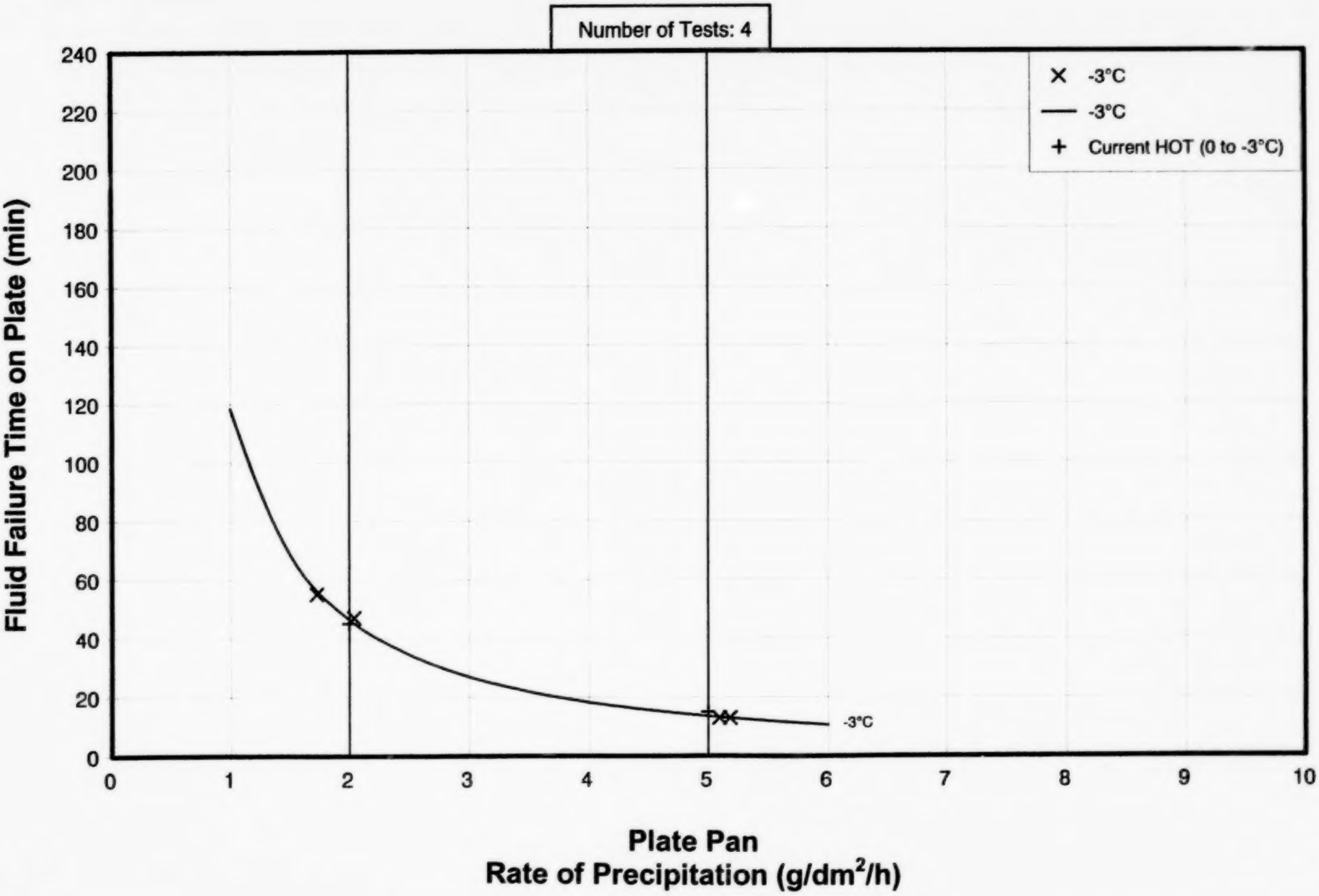
1998-99



KILFROST ABC-II PLUS 50/50

SIMULATED FREEZING FOG

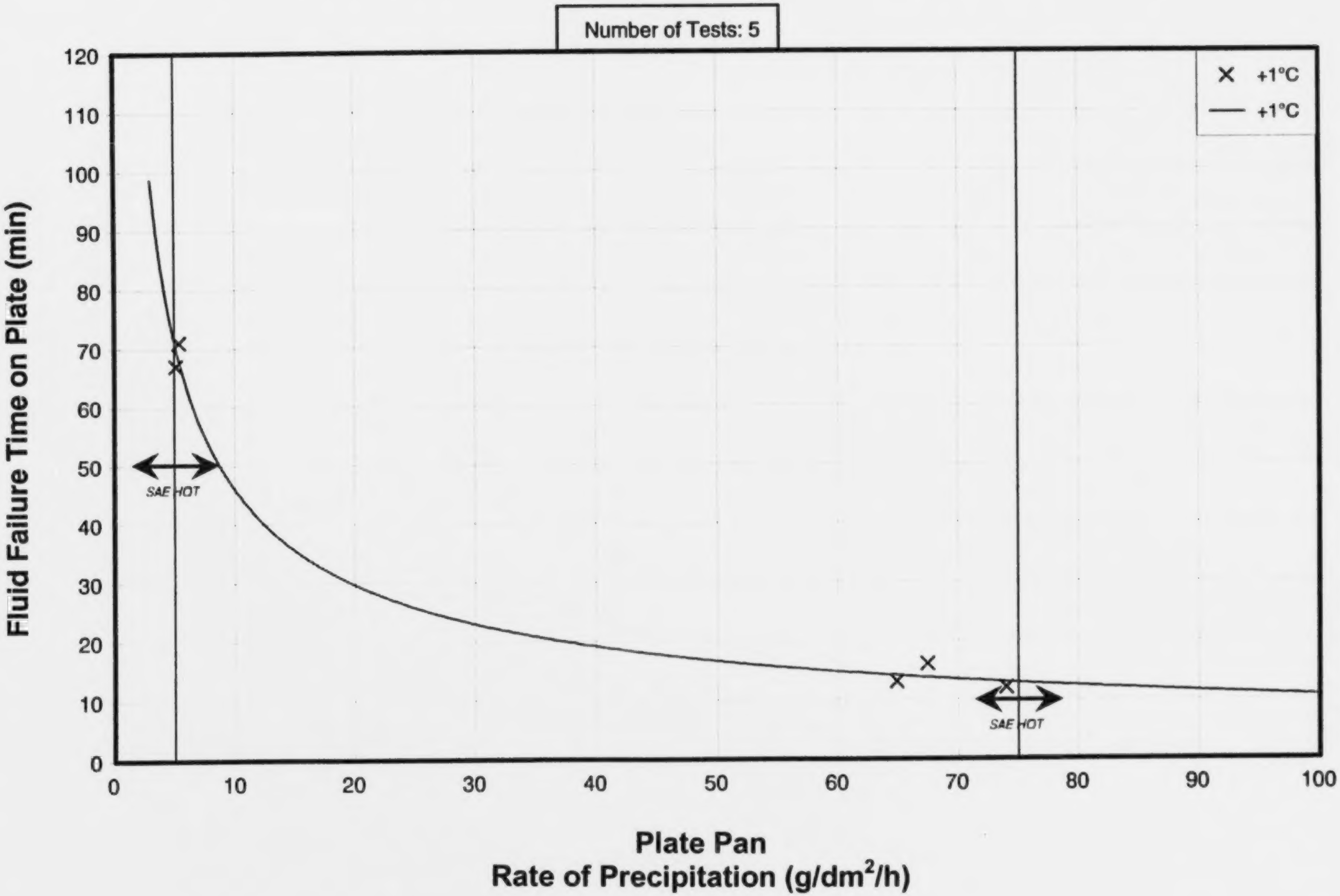
1998-99



CLARIANT SAFEWING MPIV 1957 TYPE IV NEAT

RAIN ON COLD-SOAK SURFACE

1998-99



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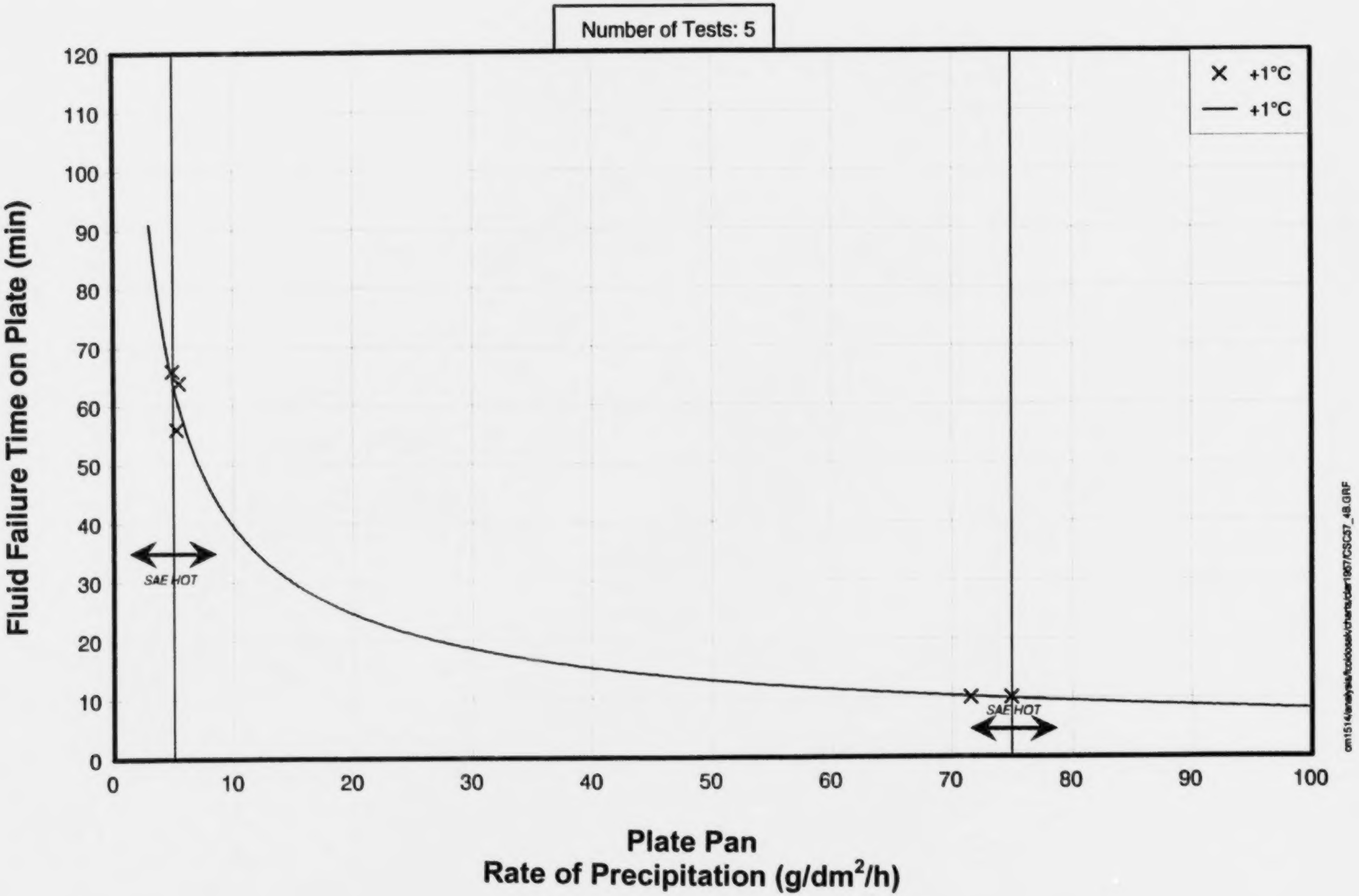
CLARIANT SAFEWING MPIV 1957 TYPE IV 75/25

RAIN ON COLD-SOAK SURFACE

1998-99

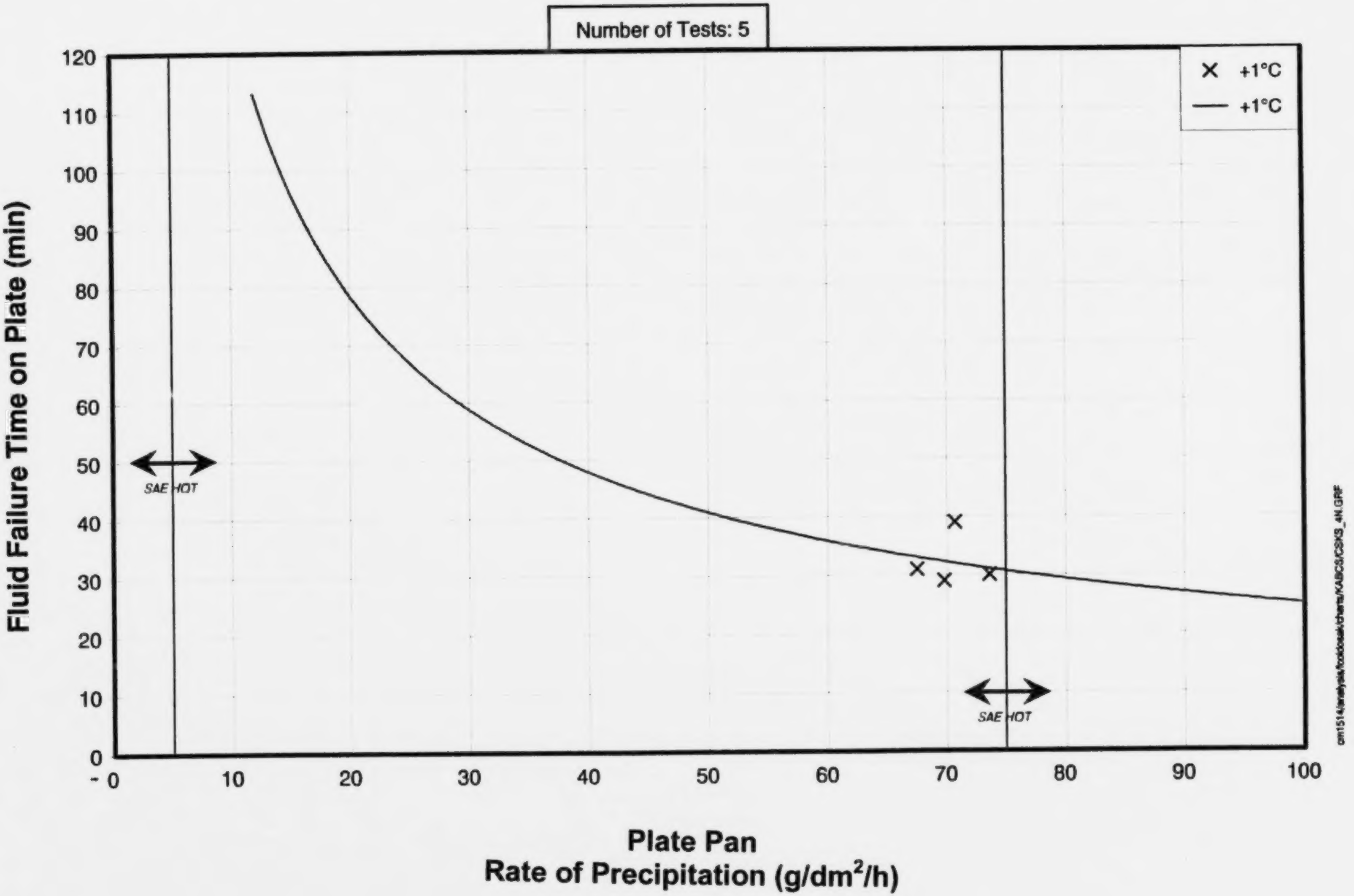


EFFECT OF RATE OF PRECIPITATION ON ENDURANCE TIME

KILFROST ABC-S TYPE IV NEAT

RAIN ON COLD-SOAK SURFACE

1998-99

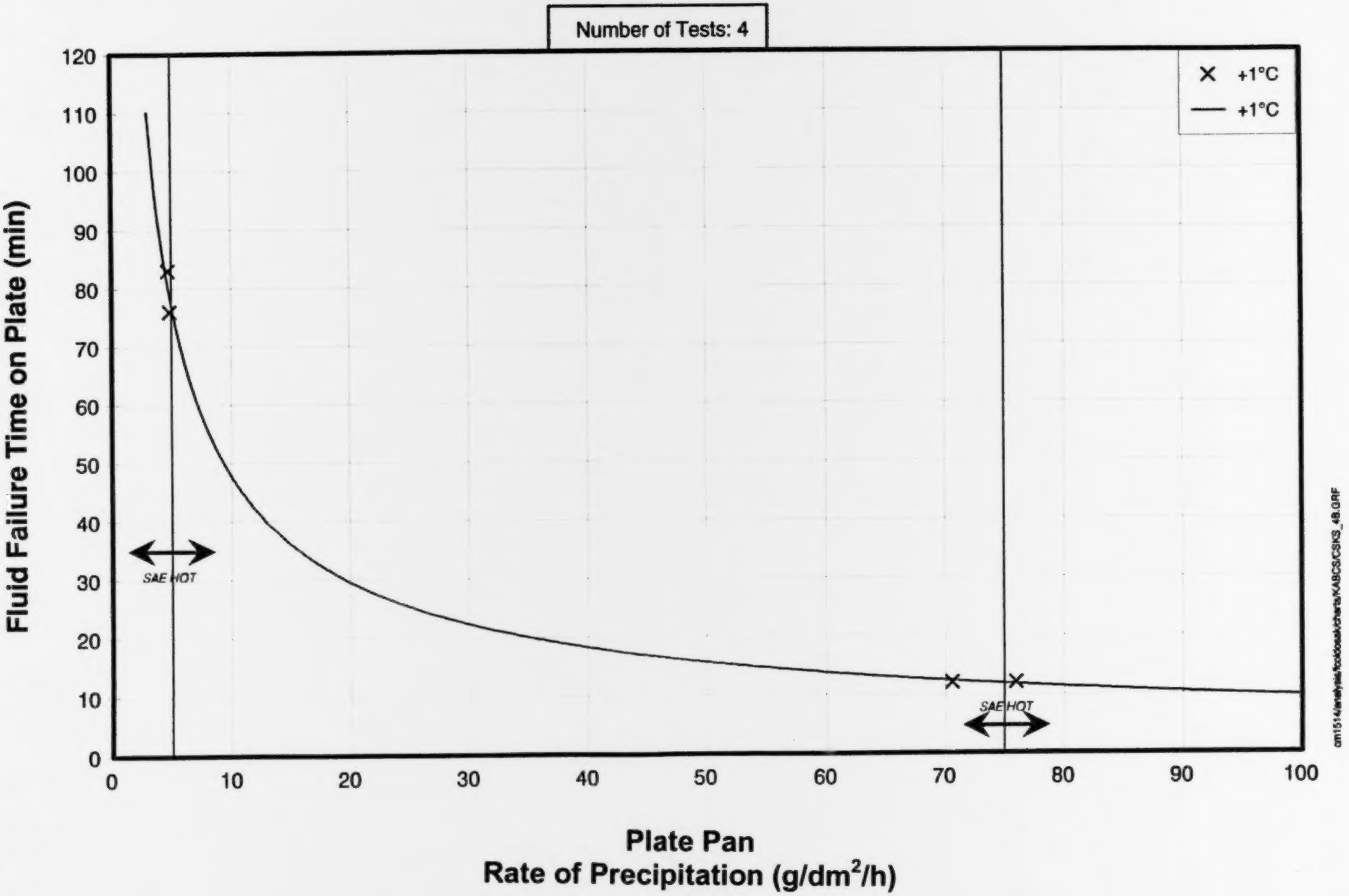


EFFECT OF RATE OF PRECIPITATION ON ENDURANCE TIME

KILFROST ABC-S TYPE IV 75/25

RAIN ON COLD-SOAKED SURFACE

1998-99

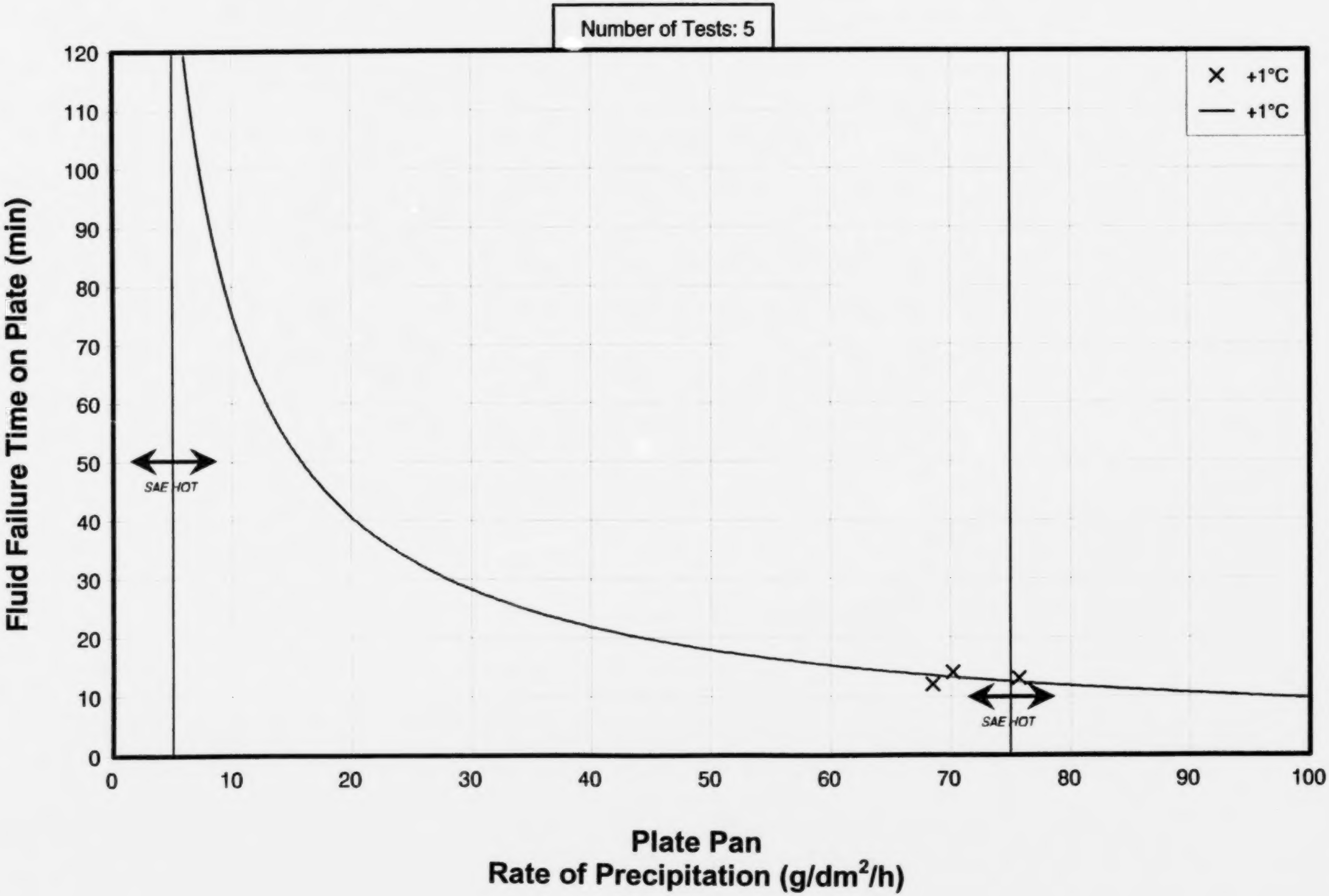


EFFECT OF RATE OF PRECIPITATION ON ENDURANCE TIME

OCTAGON MAXFLIGHT TYPE IV NEAT

RAIN ON COLD-SOAKED SURFACE

1998-99



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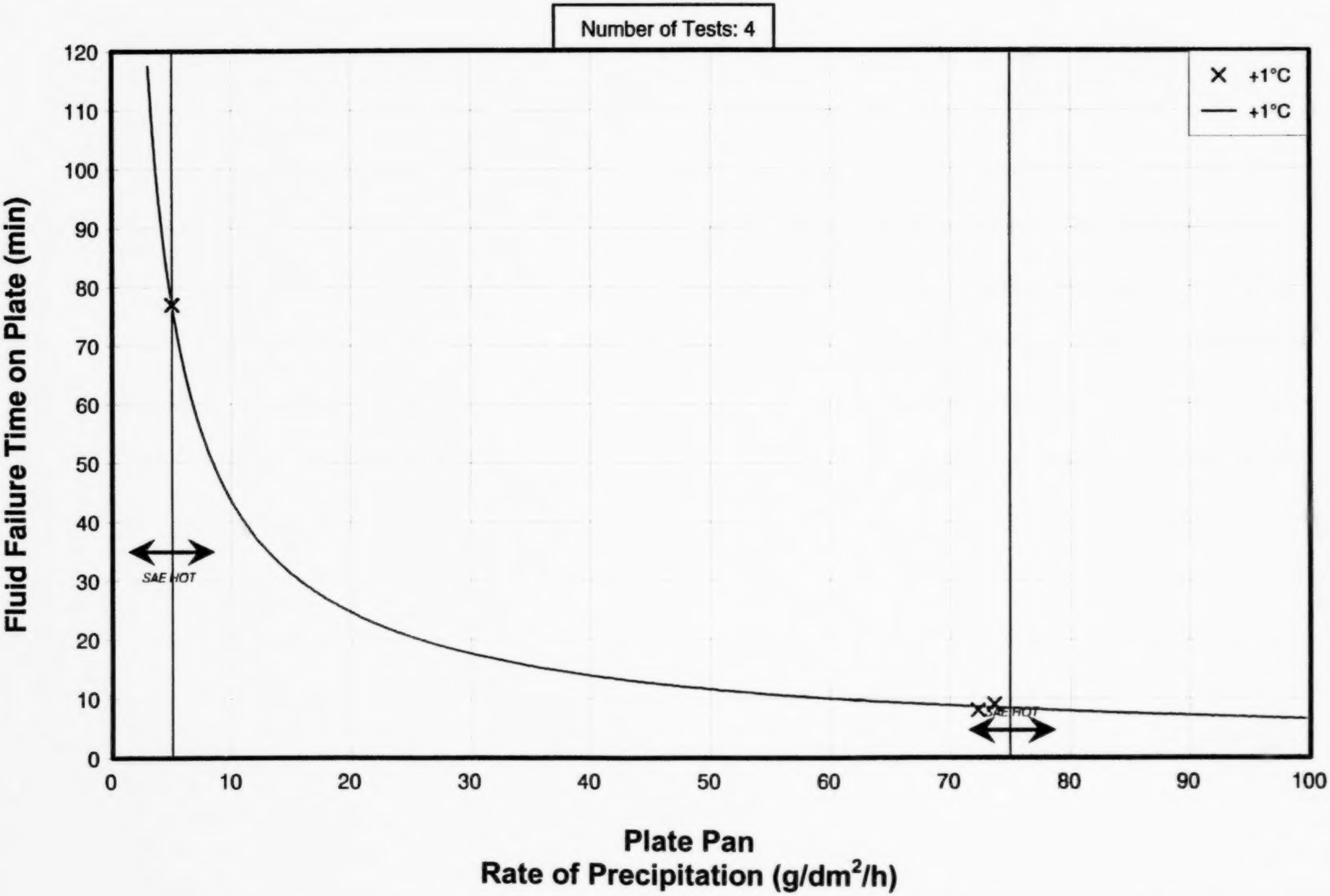
EFFECT OF RATE OF PRECIPITATION ON ENDURANCE TIME

OCTAGON MAXFLIGHT TYPE IV 75/25

RAIN ON COLD-SOAKED SURFACE

1998-99



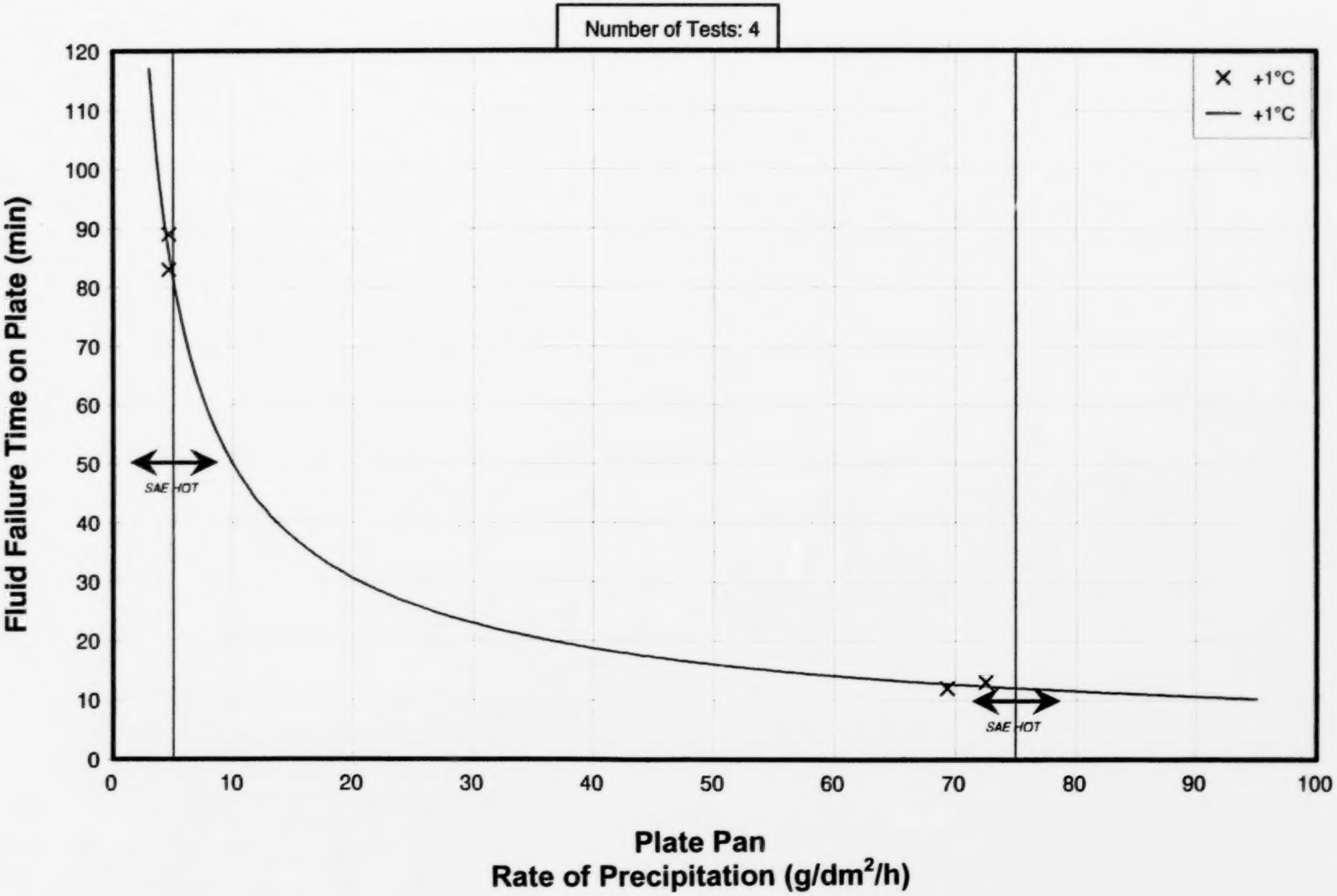
cm1514/analysis/coldsoak/charts/OCT/CSOCT_48.GRF

EFFECT OF RATE OF PRECIPITATION ON ENDURANCE TIME

UCAR ULRA + TYPE IV NEAT

RAIN ON COLD-SOAK SURFACE

1998-99

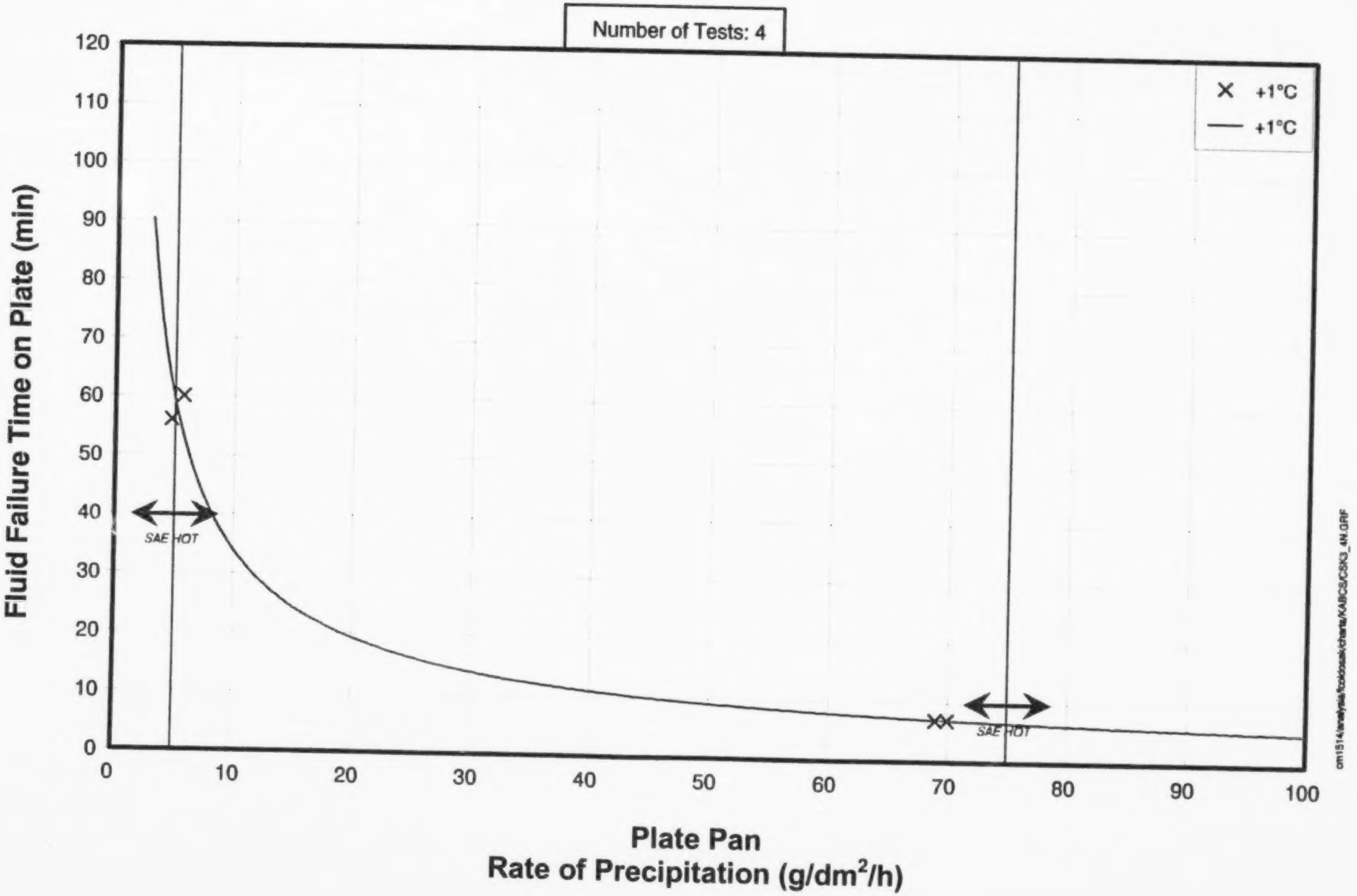


EFFECT OF RATE OF PRECIPITATION ON ENDURANCE TIME

KILFROST ABC-II PLUS NEAT

RAIN ON COLD-SOAK SURFACE

1998-99

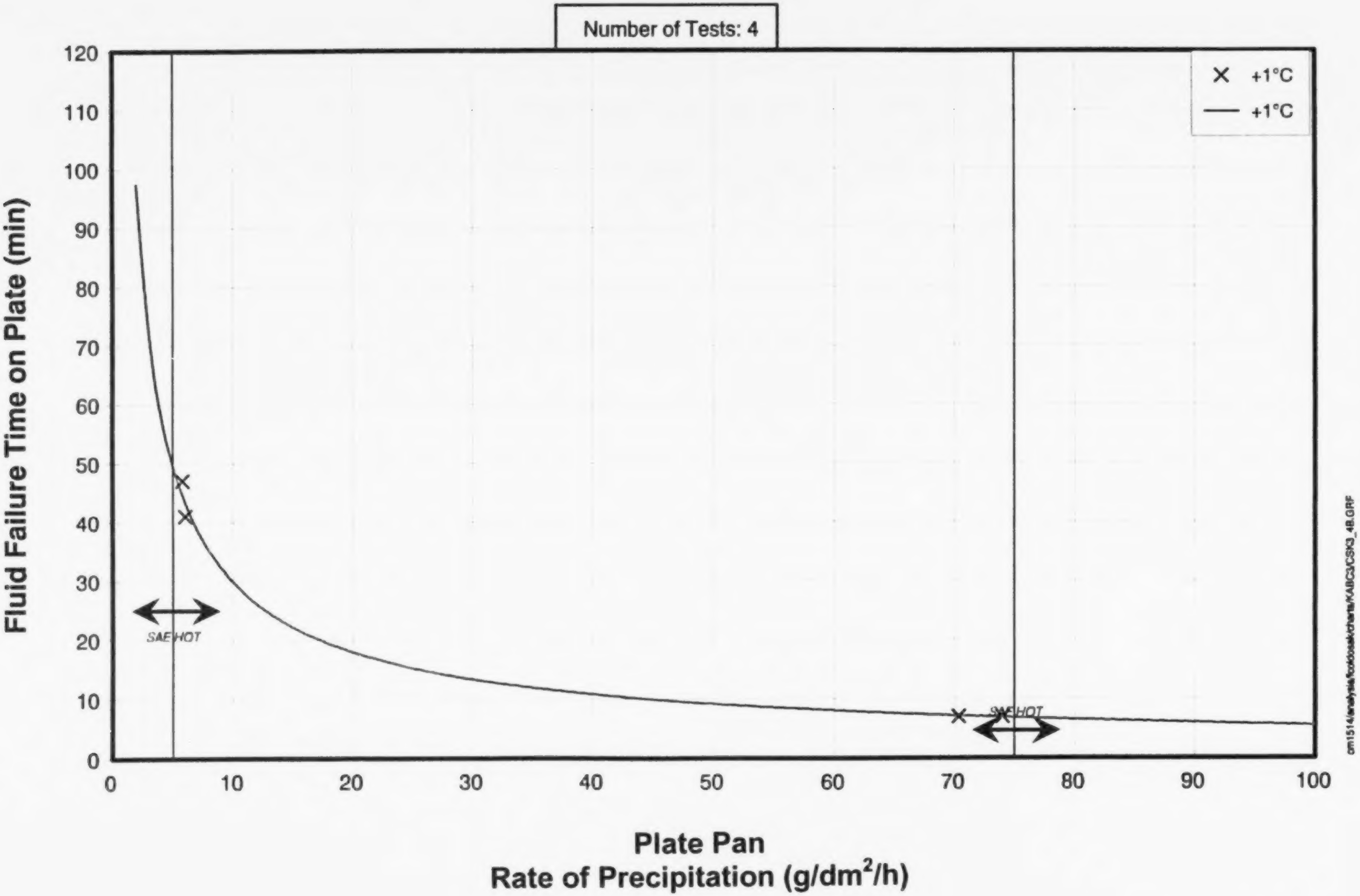


EFFECT OF RATE OF PRECIPITATION ON ENDURANCE TIME

KILFROST ABC-II PLUS 75/25

RAIN ON COLD-SOAK SURFACE

1998-99



APPENDIX G

STATISTICAL MULTI-VARIABLE REGRESSION ANALYSIS

MULTI-VARIABLE REGRESSION ANALYSIS RESULTS

TYPE IV AND II FLUIDS IN LIGHT FREEZING RAIN AT -3°C

Fluid Name	Dilution	# of Tests	Temperature (°C)	Coefficient c	Coefficient a	R^2
Clariant Safewing MPIV 1957	Neat	6	-3	2.2703	-0.5771	98.7%
	75/25	4	-3	2.2128	-0.5659	99.7%
	50/50	4	-3	2.0287	-0.7720	99.8%
Kilfrost ABC-S	Neat	4	-3	2.7943	-0.6315	97.0%
	75/25	4	-3	2.3286	-0.5836	98.4%
	50/50	4	-3	1.6395	-0.4931	97.8%
Octagon Maxflight	Neat	4	-3	2.5883	-0.8166	99.4%
	75/25	4	-3	2.8842	-1.1490	99.7%
	50/50	4	-3	1.8394	-0.6714	99.8%
FLUID X	Neat	4	-3	2.7710	-0.6533	99.9%
UCAR ULTRA +	Neat	6	-3	2.2847	-0.6144	98.7%
KILFROST ABC-II PLUS	Neat	4	-3	2.2136	-0.5470	100.0%
	75/25	4	-3	2.5992	-0.9103	99.9%
	50/50	4	-3	2.8950	-1.5416	99.8%

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MULTI-VARIABLE REGRESSION ANALYSIS RESULTS

TYPE IV AND II FLUIDS IN LIGHT FREEZING RAIN AT -10°C

Fluid Name	Dilution	# of Tests	Temperature (°C)	Coefficient c	Coefficient a	R²
Clariant Safewing MPIV 1957	Neat	6	-10	2.3813	-0.7648	99.4%
	75/25	4	-10	2.5815	-1.0104	96.5%
Kilfrost ABC-S	Neat	5	-10	3.1764	-1.5258	99.9%
	75/25	4	-10	3.5272	-1.7987	99.9%
Octagon Maxflight	Neat	4	-10	3.3700	-1.5783	99.8%
	75/25	4	-10	2.7391	-1.1448	100.0%
FLUID X	Neat	4	-10	3.4687	-1.4830	98.4%
UCAR ULTRA +	Neat	6	-10	2.4117	-0.6918	98.2%
KILFROST ABC-II PLUS	Neat	4	-10	3.0873	-1.4700	89.1%
	75/25	5	-10	2.4646	-1.0720	85.5%

MULTI-VARIABLE REGRESSION ANALYSIS RESULTS

TYPE IV AND II FLUIDS IN FREEZING DRIZZLE AT -3°C

Fluid Name	Dilution	# of Tests	Temperature (°C)	Coefficient c	Coefficient a	R²
Clariant Safewing MPIV 1957	Neat	6	-3	2.2739	-0.6291	95.8%
	75/25	4	-3	2.2755	-0.6478	98.2%
	50/50	4	-3	1.6514	-0.4239	92.0%
Kilfrost ABC-S	Neat	8	-3	2.3897	-0.2842	55.4%
	75/25	4	-3	2.1721	-0.4710	92.4%
	50/50	4	-3	1.7499	-0.5783	96.5%
Octagon Maxflight	Neat	9	-3	2.5895	-0.7476	93.0%
	75/25	7	-3	2.2982	-0.5584	85.3%
	50/50	4	-3	1.8823	-0.7043	99.4%
FLUID X	Neat	4	-3	2.4391	-0.3495	92.1%
UCAR ULTRA +	Neat	7	-3	2.5269	-0.7811	95.5%
KILFROST ABC-II PLUS	Neat	5	-3	2.3487	-0.7209	94.8%
	75/25	4	-3	2.3746	-0.8332	97.5%
	50/50	4	-3	2.4726	-1.5003	99.4%

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MULTI-VARIABLE REGRESSION ANALYSIS RESULTS

TYPE IV AND II FLUIDS IN FREEZING DRIZZLE AT -10°C

Fluid Name	Dilution	# of Tests	Temperature (°C)	Coefficient c	Coefficient a	R²
Clariant Safewing MPIV 1957	Neat	6	-10	2.3813	-0.7648	99.4%
	75/25	4	-10	2.5815	-1.0104	96.5%
Kilfrost ABC-S	Neat	5	-10	3.1764	-1.5258	99.9%
	75/25	4	-10	3.5272	-1.7987	99.9%
Octagon Maxflight	Neat	4	-10	3.3700	-1.5783	99.8%
	75/25	4	-10	2.7391	-1.1448	100.0%
FLUID X	Neat	4	-10	3.4687	-1.4830	98.4%
UCAR ULTRA +	Neat	6	-10	2.4117	-0.6918	98.2%
KILFROST ABC-II PLUS	Neat	4	-10	3.0873	-1.4700	89.1%
	75/25	5	-10	2.4646	-1.0720	85.5%

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MULTI-VARIABLE REGRESSION ANALYSIS RESULTS

TYPE IV AND II FLUIDS IN FREEZING FOG AT -3°C

Fluid Name	Dilution	# of Tests	Temperature (°C)	Coefficient c	Coefficient a	R^2
Clariant Safewing MPIV 1957	Neat	4	-3	2.3655	-0.7887	99.3%
	75/25	4	-3	2.3109	-0.6754	97.0%
	50/50	4	-3	1.9049	-0.7079	99.7%
Kilfrost ABC-S	Neat	4	-3	2.7032	-0.7245	94.4%
	75/25	4	-3	2.1889	-0.5545	97.5%
	50/50	4	-3	1.6863	-0.5068	97.8%
Octagon Maxflight	Neat	4	-3	2.5675	-0.6300	96.2%
	75/25	5	-3	2.4355	-0.6992	91.0%
	50/50	4	-3	1.8783	-0.6016	96.5%
FLUID X	Neat	4	-3	2.5948	-0.5441	99.8%
UCAR ULTRA+	Neat	4	-3	2.5966	-0.8735	87.7%
KILFROST ABC-II PLUS	Neat	5	-3	2.3862	-0.7676	98.1%
	75/25	4	-3	2.3844	-0.7612	98.3%
	50/50	4	-3	2.0733	-1.3477	99.9%

MULTI-VARIABLE REGRESSION ANALYSIS RESULTS

TYPE IV AND II FLUIDS IN FREEZING FOG AT -14°C

Fluid Name	Dilution	# of Tests	Temperature (°C)	Coefficient c	Coefficient a	R²
Clariant Safewing MPIV 1957	Neat	4	-14	2.1968	-0.7990	100.0%
	75/25	4	-14	2.2146	-1.2257	99.7%
Kilfrost ABC-S	Neat	4	-14	2.4307	-1.1131	100.0%
	75/25	4	-14	2.0461	-0.9024	98.6%
Octagon Maxflight	Neat	4	-14	2.3735	-1.0146	97.6%
	75/25	4	-14	2.1271	-0.9497	98.5%
FLUID X	Neat	4	-14	2.5764	-0.7575	99.2%
UCAR ULTRA +	Neat	4	-14	2.4990	-0.8182	99.7%
KILFROST ABC-II PLUS	Neat	4	-14	2.0675	-0.8227	99.8%
	75/25	4	-14	2.0597	-1.0188	99.7%

MULTI-VARIABLE REGRESSION ANALYSIS RESULTS

TYPE IV AND II FLUIDS IN FREEZING FOG AT -25°C

Fluid Name	Dilution	# of Tests	Temperature (°C)	Coefficient c	Coefficient a	R²
Clariant Safewing MPIV 1957	Neat	4	-25	1.8212	-0.6517	99.4%
Kilfrost ABC-S	Neat	4	-25	1.8469	-0.7299	98.3%
Octagon Maxflight	Neat	4	-25	1.7864	-0.6637	97.5%
FLUID X	Neat	4	-25	2.4333	-1.0855	97.5%
UCAR ULTRA +	Neat	4	-25	2.4726	-1.2125	99.9%
KILFROST ABC-II PLUS	Neat	4	-25	1.3335	-0.2770	96.6%

MULTI-VARIABLE REGRESSION ANALYSIS RESULTS

TYPE IV AND II FLUIDS IN COLD-SOAK CONDITIONS

Fluid Name	Dilution	# of Tests	Temperature (°C)	Coefficient c	Coefficient a	R²
Clariant Safewing MPIV 1957	Neat	5	+1	2.2966	-0.6338	98.8%
	Neat	5	+1	2.2889	-0.6911	99.6%
Kilfrost ABC-S	Neat	5	+1	2.8240	-0.7136	97.9%
	Neat	4	+1	2.3729	-0.6938	99.9%
Octagon Maxflight	Neat	5	+1	2.7731	-0.8952	99.5%
	Neat	4	+1	2.4627	-0.8232	99.8%
FLUID X	Neat	4	+1	2.8947	-0.8956	99.5%
UCAR ULTRA+	Neat	4	+1	2.4056	-0.7072	99.8%
KILFROST ABC-II PLUS	Neat	4	+1	2.3434	-0.8125	99.4%
	Neat	4	+1	2.2098	-0.7345	99.8%

APPENDIX H

OFFICIAL HOT TABLES FOR USE DURING WINTER 1999-2000

- FAA HOT Tables
- Transport Canada HOT Tables

FAA HOT TABLES

ORDER: 8400.10

APPENDIX: 4

BULLETIN TYPE: Flight Standards Information Bulletin for Air
Transportation (FSAT)

BULLETIN NUMBER: FSAT 99-07

BULLETIN TITLE: FAA-Approved Deicing Program Updates, Winter 1999-2000

EFFECTIVE DATE: 10-01-99

TRACKING NUMBER: N/A

NOTE: THIS BULLETIN REQUIRES PTRS INPUT. SEE ITEM 5.

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1. PURPOSE. This bulletin provides revised Society of Automotive Engineers (SAE) approved holdover timetables and the associated guidelines for the application of Types I, II, and IV deicing/anti-icing fluid mixtures. This bulletin also includes one additional FAA approved manufacturer specific Type II deicing/anti-icing holdover timetable (i.e., KILFROST ABC-II PLUS) and six FAA approved manufacturer specific Type IV deicing/anti-icing holdover timetables (i.e., UNION CARBIDE® ULTRA+, OCTAGON® MAX-FLIGHT, KILFROST® ABC-S, SAFEWING MPIV 1957, SAFEWING MPIV 2001, and SPCA AD-480). In addition, this bulletin presents a listing of qualified Type I,
Type II and Type IV deicing/anti-icing fluids for the 1999-2000 winter icing season. Also, this bulletin includes updated information and recommendations on various other ground deicing/anti-icing findings that have surfaced over the past year. This bulletin cancels the bulletins FSAT 97-10, FSAT 97-10A, FSAT 97-10B, and FSAT 98-17B which contained previously issued holdover timetables and other related information.

2. BACKGROUND.

A. Title 14 of the Code of Federal Regulations (14 CFR) part 121, section 121.629(c) requires that part 121 certificate holders have an approved ground deicing/anti-icing program unless the certificate holder complies with section 121.629(d). Advisory Circular (AC) 120-60, Ground Deicing And Anti-Icing Program, provides guidance for obtaining approval of a ground deicing/anti-icing program and discusses the use of holdover times. Title 14 CFR part 135, section 135.227(b)(3) allows a part 135 certificate holder to comply with a part 121 approved program.

B. Additional guidance on holdover timetables is contained in AC 120-58, Pilot Guide For Large Aircraft Ground Deicing, AC 135-17, Pilot Guide-Small Aircraft Ground Deicing, and AC 20-117, Hazards Following Ground Deicing And Ground Operations In Conditions Conducive To Aircraft Icing. As of the publication of this bulletin the above referenced advisory material is being updated. Revised material will be distributed as soon as it becomes available.

3. DISCUSSION.

A. Holdover-time (HOT) timetables: Attached are revised FAA approved SAE holdover timetables as well as FAA-approved SAE guidelines for the application of Types I, II, and IV deicing/anti-icing fluids. Because of the difference in performance of specific Type II and specific Type IV deicing/anti-icing fluids available for this winter season, nine (two Type II and seven Type IV) different approved holdover timetables are attached. These include the SAE and Kilforst ABC II Plus Type II holdover timetables, and the SAE, UNION CARBIDE® ULTRA+, OCTAGON® MAX-FLIGHT, KILFROST® ABC-S, CLARIANT MPIV 1957, CLARIANT MPIV 2001, and SPCA AD-480 Type IV holdover timetables. Air carriers may only use these manufacturer specific tables when these specific fluids are used during the deicing/anti-icing process. If it can not be positively determined which specific Type II or Type IV fluid was used during the deicing/anti-icing process air carriers must use the holdover times from the SAE Type II or Type IV fluid holdover timetable, as appropriate. As initially indicated in FSAT 97-10B, the holdover times for ® ULTRA+ Type IV fluid is valid only when it is applied in the 100/0 concentration. Also included is a list, by manufacturer brand name, of qualified Type I, Type II and Type IV deicing/anti-icing fluids.

B. Distribution: These tables should be distributed to all part 121 and part 135 certificate holders who have an approved part 121 deicing/anti-icing programs. These holdover timetables and associated guidelines should also be distributed to operators who are not required to have an approved program, but who deice or anti-ice with fluids and use holdover timetables during winter weather operations. The attached timetables and guidelines supersede all previously approved holdover timetables and guidelines for the application of deicing/anti-icing fluid mixtures.

C. Unique Holdover Times: The SAE holdover timetables are constructed to present information on the minimum performance times that have been observed during testing of the deicing/anti-icing fluids. Typically, for the conditions of

FREEZING FOG, SNOW, FREEZING DRIZZLE, and LIGHT FREEZING RAIN, each cell of the HOT values are representative of a range of performance times in which the fluids provide acceptable protection for varying precipitation intensities. The lower holdover time value in a cell presents information for moderate precipitation conditions and the longer holdover time is representative of fluid performance for light precipitation conditions. On the SAE Type IV holdover timetable for the conditions of FREEZING DRIZZLE and LIGHT FREEZING RAIN the holdover times values are the same for both the 100/0 and the 75/25 fluid concentrations in the temperature range of -3° to -14° C. These values are 20-55 minutes for FREEZING DRIZZLE and 10-30 minutes for LIGHT FREEZING RAIN. Although appearing to be in error, these values are correct. They are a conglomerate of the minimum performance times of three different Type IV deicing/anti-icing fluids in which the holdover time performance of these fluids in the 75/25 concentration equals or exceeds their performance for 100/0 concentrations. Details of this phenomenon can be gleaned from a review of the appropriate cells from the manufacturer specific holdover time tables for ABC-S, MAX-FLIGHT and Safewing MP IV-1957 Type IV fluids. This phenomenon can be attributed to the fact that the addition of water to some neat Type IV fluids can enhance their performance up to point. Adding water has the effect of allowing the fluid to build up thicker on a surface. Typically, the thicker the fluid, the longer the holdover time performance. Without knowing about this particular fluid/water mix phenomenon an air carrier may think that the data presented in the tables is in error. Fluid failure is complex, dependent on outside air temperature (OAT), percent mix, type and rate of precipitation, and other variables. One should keep in mind that the phenomenon exhibited by ABC-S, MAXFLIGHT and Safewing MP IV 1957 for theses precipitation conditions are not consistent with all variables or for all other neat fluids.

D. Holdover Time Changes: The holdover times for most Type IV fluids will be lower in some cells than the previous year. This is due to a requirement to test Type IV fluids at the lowest on-wing viscosity. The viscosity and the method of measurement are noted at the top of each manufacturer's specific Type IV HOT chart and is for the user's information. It is not anticipated that this viscosity and measurement information will be used by, or made available to, flightcrews. However, the user may, if elected to do so, verify the on-wing viscosity to assure that the holdover times expected are commensurate with those in the corresponding table. Note, however, that differences in pumping equipment can result in varying degrees of fluid shearing/degradation with corresponding variations in viscosity measurement. This may result in a slight deviations from published HOT values. In all cases, however, the fluids noted in this bulletin have been fully qualified and the HOT charts associated with each fluid are, as with all HOT charts, guidelines only.

(1) The note pertaining to the last two cells under the "Freezing Drizzle" and "Light Freezing Rain" columns, for Types II and IV fluids, has been changed. It now reads "No holdover time guidelines exist for this condition below -10° C (14° F)". On rare occasions precipitation conditions have been known to occur below this temperature and caution should be exercised regarding HOT values when such events do occur. Actual holdover

times may be considerably reduced from those in these tables under extreme low temperature conditions.

(2) On all HOT guideline charts a new column has been added with a heading of "OTHER‡". This new column with its supporting note delineates the fact that no HOT guidelines exist for the conditions of snow pellets, snow grains, ice pellets, moderate and heavy freezing rain and hail. As such, air carriers should not attempt takeoff in conditions of snow pellets, snow grains, ice pellets or hail unless operations in these conditions are approved by the aircraft manufacturer and a pretakeoff contamination check is performed. Takeoffs in conditions of moderate and heavy freezing rain are not approved.

E. Fluid Dry-Out: There have been reported incidents of restricted movement of flight control surfaces, while in-flight, attributed to fluid dry-out. Such events may occur with repeated use of Type IV (and possibly Type II) fluids, without prior application of hot water or Type I fluid mixtures. This can result in fluids collecting in aerodynamically quiet areas or crevices which do not flow off the wing during the take-off ground roll. This may lead to an accumulation of fluids in these aerodynamically quiet areas which can dry to a gel-like or powdery substance. Such residues have been known to rehydrate and expand under certain atmospheric conditions, such as high humidity or rain, and then subsequently freeze, typically during flight at higher altitudes. This can be especially critical for unpowered control surfaces such as trim tabs. Some pilots reportedly have reduced altitude until the frozen fluid melts, thus restoring flight control movement. Such occurrences have not been reported when a two step deicing/anti-icing procedure is used in which the first step is a hot Type I fluid mixture or hot water. It has been suggested that high pressure washing, with a hot Type I fluid/water mix in areas where fluids could accumulate, may alleviate the problem. Such a procedure may require subsequent lubrication. If not successful, fluid dry-out may become a maintenance issue, in which case appropriate procedures are necessary to address the problem. Increasing the frequency of inspection may be a necessity if fluid dry-out with consequent restricted flight control movement becomes a recurring problem. Operators who deice with hot water or a Type I fluid/water mixture and anti-ice with a Type IV(or II) have not reported such a dry-out problem. Aircraft surfaces, quiet areas and crevices should be checked for abnormal fluid thickening, appearance or failure, prior to flight dispatch, especially if Type II or IV fluids are used exclusively. This residue may require removal.

F. Frost: In the past several inquiries have been raised relative to active frost. Active frost is a frost condition that is actively growing crystals and gaining in mass and thickness and is considered a precipitation condition. It typically forms at night under clear skies and calm winds when the OAT is below 0°C/32°F and the dew point temperature spread is less than 3° Celsius. The temperature of the aircraft surface must be below 0°C/32°F. As an example, if an aircraft is parked outdoors on a cold clear night, heat can radiate from its surface at a rate greater than is absorbed from its surroundings. The net effect is that the aircraft surface temperature drops below the OAT. If this temperature is below the frost point temperature of the air, moisture will deposit in the form of hoarfrost.

(1) As a guide, if there is frost on any object in the deicing area (including the aircraft) and the OAT and dew point are 3°C apart and narrowing there is likely to be active frost. If the OAT and dew point are 3°C apart and expanding, it is not clear if there is active frost. Therefore, if there is doubt, the condition should be treated as active frost. Weather forecasts and METARs usually do not provide information on frost conditions.

(2) Thin hoarfrost is acceptable on the upper surface of the aircraft fuselage provided all vents and ports are clear. This hoarfrost is usually a uniform white deposit of fine crystalline texture as indicated above, and is thin enough to allow one to visually distinguish aircraft paint surface features underneath it, such as paint lines, markings and lettering.

4. ACTION.

A. Principal operations inspectors (POI) shall ensure that the attached approved holdover timetables and application guidelines are made available to affected certificate holders and incorporated into their procedures or programs. Certificate holders should use these tables and application guidelines or use the data contained in the attached tables and guidelines to develop tables and guidelines that are acceptable to the Administrator.

B. Principal operations inspectors shall ensure their assigned air carrier's approved ground deicing/anti-icing program is revised to include the following updates for the 1990-2000 winter season:

(1) Fluid Application.

(a) Surveillance of deicing/anti-icing operations during prior seasons have indicated several problems in the fluid application area. These findings include:

i Instances when the application of fluid was applied in the reverse order of company approved procedures, (e.g., approved procedure being wing tip to wing root),

ii Insufficient fluid temperature buffer, and

iii Incomplete removal of contamination.

(b) Ground testing of Type II and IV fluids indicates that the effectiveness of these fluids is highly dependent on the training and skill of the individual applying the fluid. When these fluids are used, ground personnel should ensure that they are evenly applied so that all critical surfaces, especially the leading edge of the wings, are covered with fluid. In addition, it has been indicated that an insufficient amount of anti-icing fluid, especially in the second step of a two step procedure, may cause reduced holdover times due to the uneven application of the second step fluid. The effects of trace icing on aircraft performance vary according to the type of aircraft. Many aircraft experience little or no noticeable effect while other types may experience significant loss of performance or controllability. A report of trace icing should not be disregarded. All reports of inflight icing should be considered as potentially hazardous.

(2) Communication.

(a) Communication between all personnel involved in the air carrier's approved program is critical to ensuring the pilot has the information needed to make the final determination that the aircraft is free of contamination prior to flight. Approved programs should emphasize that all personnel (e.g., management personnel, dispatchers, ground personnel, and flight crew members) who perform duties as outlined in the approved program communicate clearly and concisely essential information needed to ensure the clean aircraft concept is attained. At two centralized deicing facilities in Canada the use of electronic signs have been introduced to aid in the transmission of critical information to the flight crews. This includes both aircraft ground control information at the deicing pad and information on the ongoing deicing/anti-icing procedure and fluid application.

(b) Specifically, approved programs should be reviewed to ensure that ground personnel accomplishing the deicing/anti-icing procedure communicates to the pilot, the Type fluid used (for Type II and Type IV fluids the specific manufacturer name and type fluid or SAE Type II or SAE Type IV), the percentage of fluid within the fluid/water mixture, and the local time the beginning of the final deicing/anti-icing began. The results of the post-deicing/ anti-icing check should also be reported to the pilot unless the approved program has other procedures for ensuring this information is conveyed to the pilot. Although reporting the results of the post-deicing/anti-icing check may be redundant in some cases, it is one method to confirm to the pilot that all contamination has been removed from the aircraft.

(3) Representative Surfaces/where Fluids Tend to Fail First. Preliminary aircraft testing during the past year indicates that the first fluid failures on test aircraft appear to occur on the leading or trailing edges of the wing's surface rather than the mid-chord section of the wing. Tests also indicate that fluid failures may be difficult to identify. Principal operations inspectors should reevaluate those aircraft representative surfaces currently included within the air carrier's approved program to ensure that representative surfaces provide the pilot a proper indication of the status of the aircraft's critical surfaces. Where possible, representative surfaces should include at least a portion of the wing leading edge.

(4) Type III Deicing/Anti-icing Fluids. It is not anticipated that Type III deicing/anti-icing will be available during the 1999-2000 winter icing season.

(5) New Technology.

(a) Principal operations inspectors should make their assigned air carriers aware of the new technology that has been introduced or improved over the last year. There have been several ice detection systems developed and tested during the past year. These include wide area hand held ice detection systems that use advanced optical technology capable of quickly detecting aircraft contamination from distances up to 200 feet from the aircraft. One of these advance optical systems has been approved as part of an air carrier's approved program. Another, a vehicular mounted ice detection system has been placed in service at the Centralized Aircraft Deicing Facility at Pearson International Airport in Toronto, Canada. This optical system employs a video-based sensor mounted on the booms of the deicing trucks with a display mounted in the cabs or in the deicing buckets. Another wide area coverage sensor, employing an infrared variant of this technology, is planned to undergo evaluation by another airline during the 1999-2000 winter icing season.

(b) At several airports, a gas fired infrared system that is installed in a modular tent/shelter facility has been place into operation. This system employs gas fired units which are suspended from the ceiling of the tent/shelter facility and imparts sufficient infrared focused energy on the aircraft surfaces to melt the frozen contaminants on its surfaces that are in the line-of-sight of the infrared heater units. This system has been employed primarily in the deicing of commuter sized aircraft; however, demonstrations have shown it to be effective in the deicing of moderate size (B-727) aircraft. Following the deicing procedure an anti-icing coating is usually applied when there is precipitation or the OAT is at or below freezing.

(c) Also, a mobile infrared deicing system is being developed which melts frozen contaminants from exposed aircraft surfaces. This system consists of a moveable, boom mounted heating panel installed on a truck. During operations these heater panels are normally situated several feet from the aircraft surfaces and employ temperature sensors to measure aircraft surface temperatures. It is anticipated that these units will usually be employed in pairs (or more).

(d) Several other manufacturers are developing vehicular mounted deicing systems which use both forced/heated air and deicing fluid mixtures to remove snow and ice accumulations from aircraft surfaces. These systems may employ two separate nozzles to spray the deicing fluid mixtures and the forced/heated air or they may employ a co-axial nozzle in which the glycol mixture and the forced/heated air is combine and then sprayed through a single orifice. The forced/heated air from these systems are typically delivered at a velocity of about 700 mph and at 10-15 psi. In order to achieve this high velocity airflow at required pressures and flow rates, some form of compressor/supercharger is used. Typically, the heat imparted to the airflow is the result of compression and not from a direct heat source. These systems are purported to significantly reduce the amounts of glycol used in the deicing process. During the upcoming winter icing season several operators will collect data on the performance of these forced/heated air-glycol hybrid deicing systems.

(e) Additionally, under development is a system whereby fuel temperature is elevated above freezing (typically 80°-85° F) and transferred to an aircraft's fuel tanks. Heat transfer from the warmer fuel to the aircraft structure is intended to facilitate deicing by reducing the amount of glycol required in the deicing process.

(f) The Federal Aviation Administration's Air Transportation Operations Division (AFS-200) is currently developing guidance for approving these advanced technology systems and facilities. For further information concerning these innovations, POIs may contact AFS-200 at (202) 267-8166.

(6) Operations during Light Freezing Rain/Freezing Drizzle.

(a) Principal operations inspectors should strongly encourage air carriers electing to operate in light freezing rain or freezing drizzle weather conditions to use Type II or IV anti-icing fluids. Also, POIs should ensure that approved programs clearly state that deicing/anti-icing fluids do not provide any protection from contamination once the aircraft is airborne.

(b) Principal operations inspectors should ensure that air carriers who elect not to use Type II or Type IV anti-icing fluids during light freezing rain or freezing drizzle conditions, develop and use special procedures for operating during these weather conditions. Examples of special procedures would include an approved external pre-takeoff contamination check, a remote deicing capability, or other special means of enhancing the safety of operation during these conditions such as the use of advanced wide area optical technology capable of detecting aircraft contamination.

(c) Principal operations inspectors should use special emphasis surveillance during periods of light freezing rain and freezing drizzle to ensure that approved checks or other special procedures, as stated above, are effective and conducted in accordance with the air carrier's approved deicing/anti-icing program.

5. PROGRAM TRACKING AND REPORTING SUBSYSTEM (PTRS) INPUT. Principal operations inspectors shall make a PTRS entry to record the actions directed by this bulletin with each of their operators as outlined in HBAT 94-08. The PTRS entry shall be listed as Activity Code No. 1381 and entered into the National Use field as FSAT9907. Principal operations inspectors should use the comments section to record comments of interaction with the operators.

6. INQUIRIES. This bulletin was developed by AFS-200. Any questions or comments should be directed to Daniel Meier, AFS-220, at (202)267-3749.

7. EXPIRATION. This bulletin expires October 31, 2000.

/s/
Quentin J. Smith, Jr.
Manager, Air Transportation Division

ATTACHMENTS

TABLE 1 - Guideline for Holdover Times Anticipated for SAE Type I Fluid Mixture as a Function of Weather Conditions and OAT

CAUTION: THIS TABLE IS FOR USE IN DEPARTURE PLANING ONLY, AND IT SHOULD BE USED IN CONJUNCTION WITH PRE-TAKEOFF CHECK PROCEDURES.

OAT		Approximate Holdover Times Under Various Weather Conditions (hours: minutes)						
°C	°F	*Frost	Freezing Fog	Snow	**Freezing Drizzle	Light Freezing Rain	Rain on Cold Soaked Wing	Other‡
above 0	above 32	0:45	0:12-0:30	0:06-0:15	0:05-0:08	0:02-0:05	0:02-0:05	CAUTION: No holdover time guidelines exist
0 to -10	32 to 14	0:45	0:06-0:15	0:06-0:15	0:05-0:08	0:02-0:05	CAUTION: Clear ice may require touch for confirmation	
below -10	below 14	0:45	0:06-0:15	0:06-0:15				

°C Degrees Celsius
°F Degrees Fahrenheit
OAT Outside Air Temperature
FP Freezing Point

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER.

* During conditions that apply to aircraft protection for ACTIVE FROST
** Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
‡ Snow pellets, snow grains, ice pellets, moderate and heavy freezing rain, hail

SAE Type I fluid/water mixture is selected so that the FP of the mixture is at least 10°C (18°F) below OAT

CAUTION: THE TIME OF PROTECTION WILL BE SHORTENED IN HEAVY WEATHER CONDITIONS. HEAVY PRECIPITATION RATES OR HIGH MOISTURE CONTENT, HIGH WIND VELOCITY OR JET BLAST WILL REDUCE HOLDOVER TIME BELOW THE LOWEST TIME STATED IN THE RANGE. HOLDOVER TIME MAY BE REDUCED WHEN AIRCRAFT SKIN TEMPERATURE IS LOWER THAN OAT.

CAUTION: SAE TYPE I FLUID USED DURING GROUND DEICING/ANTI-ICING IS NOT INTENDED FOR AND DOES NOT PROVIDE PROTECTION DURING FLIGHT.

Effective: October 1, 1999

TABLE 1A - Guidelines for the application of SAE Type I fluid mixtures.
Minimum Concentrations as a Function of Outside Air Temperature(OAT)
Concentrations in % V/V

Outside Air Temperature OAT	One-step Procedure Deicing/anti-icing	Two-step Procedure	
		First step: Deicing	Second step Anti-icing [1]
-3° C (27° F) and above	FP of heated fluid[2] mixture shall be at least 10° C (18°F) below OAT	Water heated to 60° C (140° F) minimum at the nozzle or a heated mix of fluid and water	FP of fluid mixture shall be at least 10° C (18° F) below actual OAT
Below -3° C (27° F)		FP of heated fluid mixture shall not be more than 3° C (5° F) above OAT	

Note: For heated fluids, a fluid temperature not less than 60° C (140° F) at the nozzle is desirable. Upper temperature limit shall not exceed fluid and aircraft manufacturers recommendations.

Caution: Wing skin temperatures may differ and in some cases may be lower than OAT. A stronger mix (more Glycol) can be used under the latter conditions.

1) To be applied before first step fluid freezes, typically within 3 minutes.
2) Clean aircraft may be anti-iced with unheated fluid.

Effective: October 1, 1999

TABLE 2 - Guideline for Holdover Times Anticipated for SAE Type II Fluid Mixtures as a Function of Weather Conditions and OAT

CAUTION: THIS TABLE IS FOR USE IN DEPARTURE PLANNING ONLY, AND IT SHOULD BE USED IN CONJUNCTION WITH PRE-TAKEOFF CHECK PROCEDURES.

OAT		SAE Type II Fluid Concentration Neat-Fluid/Water (Vol. %/Vol. %)	Approximate Holdover Times under Various Weather Conditions (hours: minutes)						
°C	°F		*Frost	Freezing Fog	Snow	***Freezing Drizzle	Light Freezing Rain	Rain on Cold Soaked Wing	Other‡
above 0	above 32	100/0	12:00	1:05-2:15	0:20-1:00	0:30-1:00	0:15-0:30	0:05-0:40	CAUTION: No holdover time guidelines exist
		75/25	6:00	0:50-1:45	0:15-0:40	0:20-0:45	0:10-0:25	0:05-0:25	
		50/50	4:00	0:15-0:35	0:05-0:15	0:05-0:20	0:05-0:10	CAUTION: Clear ice may require touch for confirmation	
0 to -3	32 to 27	100/0	8:00	0:35-1:30	0:20-0:45	0:30-1:00	0:15-0:30		
		75/25	5:00	0:25-1:00	0:15-0:30	0:20-0:45	0:10-0:25		
		50/50	3:00	0:15-0:35	0:05-0:15	0:05-0:20	0:05-0:10		
below -3 to -14	below 27 to 7	100/0	8:00	0:30-1:05	0:15-0:35	**0:15-0:45	**0:10-0:30		
		75/25	5:00	0:20-:55	0:15-0:25	**0:15-0:30	**0:10-0:20		
below -14 to -25	below 7 to -13	100/0	8:00	0:15-0:20	0:15-0:30				
below -25	below -13	100/0	SAE Type II fluid may be used below -25°C (-13°F) provided the freezing point of the fluid is at least 7°C (13°F) below the OAT and the aerodynamic acceptance criteria are met. Consider use of SAE Type I when SAE Type II fluid cannot be used.						

°C	**Degrees Celsius**
°F	**Degrees Fahrenheit**
OAT	**Outside Air Temperature**
VOL	**Volume**

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER.

* During conditions that apply to aircraft protection for ACTIVE FROST

** No holdover time guidelines exist for this condition below -10 °C (14 °F)

*** Use light freezing rain holdover times if positive identification of freezing drizzle is not possible

‡ Snow pellets, snow grains, ice pellets, moderate and heavy freezing rain, hail

CAUTION: THE TIME OF PROTECTION WILL BE SHORTENED IN HEAVY WEATHER CONDITIONS. HEAVY PRECIPITATION RATES OR HIGH MOISTURE CONTENT, HIGH WIND VELOCITY OR JET BLAST MAY REDUCE HOLDOVER TIME BELOW THE LOWEST TIME STATED IN THE RANGE. HOLDOVER TIME MAY BE REDUCED WHEN AIRCRAFT SKIN TEMPERATURE IS LOWER THAN OAT.

CAUTION: SAE TYPE II FLUID USED DURING GROUND DEICING/ANTI-ICING IS NOT INTENDED FOR AND DOES NOT PROVIDE PROTECTION DURING FLIGHT.

Effective: October1, 1999

TABLE 2A - Guideline for Holdover Times Anticipated for KILFROST ABC-II PLUS Type II Fluid Mixtures as a Function of Weather Conditions and OAT – ***Viscosity of Neat Fluid Tested 3,600cp, 20°C, 0.3RPM, Spindle LV2, 250ml beaker, 150 ml fluid,10 min., grd. leg***

CAUTION: THIS TABLE IS FOR USE IN DEPARTURE PLANNING ONLY, AND IT SHOULD BE USED IN CONJUNCTION WITH PRE-TAKEOFF CHECK PROCEDURES.

OAT		SAE Type II Fluid Concentration Neat-Fluid/Water (Vol. %/Vol. %)	Approximate Holdover Times under Various Weather Conditions (hours: minutes)						
°C	°F		*Frost	Freezing Fog	Snow	***Freezing Drizzle	Light Freezing Rain	Rain on Cold Soaked Wing	Other‡
above 0	above 32	100/0	12:00	1:10-2:25	0:35-1:20	0:35-1:10	0:30-0:40	0:05-1:00	CAUTION: No holdover time guidelines exist
		75/25	6:00	1:10-2:25	0:35-1:10	0:30-1:00	0:20-0:40	0:05-0:50	
		50/50	4:00	0:15-0:45	0:20-0:40	0:05-0:25	0:05-0:15	CAUTION: Clear ice may require touch for confirmation	
0 to -3	32 to 27	100/0	8:00	1:10-2:25	0:25-0:55	0:35-1:10	0:30-0:40		
		75/25	5:00	1:10-2:25	0:25-0:50	0:30-1:00	0:20-0:40		
		50/50	3:00	0:15-0:45	0:15-0:35	0:05-0:25	0:05-0:15		
below -3 to -14	Below 27 to 7	100/0	8:00	0:30-1:05	0:15-0:35	**0:15-0:45	**0:10-0:30		
		75/25	5:00	0:20-0:55	0:15-0:35	**0:15-0:30	**0:10-0:20		
Below -14 to -25	Below 7 to -13	100/0	8:00	0:15-0:20	0:15-0:30				
below -25	below -13	100/0	KILFROST ABC-II PLUS Type II fluid may be used below -25°C (-13°F) provided the freezing point of the fluid is at least 7°C (13°F) below the OAT and the aerodynamic acceptance criteria are met. Consider use of SAE Type I when SAE Type II fluid cannot be used.						

°C	**Degrees Celsius**
°F	**Degrees Fahrenheit**
OAT	**Outside Air Temperature**
VOL	**Volume**

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER.

*	During conditions that apply to aircraft protection for ACTIVE FROST
**	No holdover time guidelines exist for this condition below -10 °C (14 °F)
***	Use light freezing rain holdover times if positive identification of freezing drizzle is not possible
‡	Snow pellets, snow grains, ice pellets, moderate and heavy freezing rain, hail

CAUTION: THE TIME OF PROTECTION WILL BE SHORTENED IN HEAVY WEATHER CONDITIONS. HEAVY PRECIPITATION RATES OR HIGH MOISTURE CONTENT, HIGH WIND VELOCITY OR JET BLAST MAY REDUCE HOLDOVER TIME BELOW THE LOWEST TIME STATED IN THE RANGE. HOLDOVER TIME MAY BE REDUCED WHEN AIRCRAFT SKIN TEMPERATURE IS LOWER THAN OAT.

CAUTION: KILFROST ABC-II PLUS TYPE II FLUID USED DURING GROUND DEICING/ANTI-ICING IS NOT INTENDED FOR AND DOES NOT PROVIDE PROTECTION DURING FLIGHT.

Effective: October1, 1999

TABLE 4 - Guideline for Holdover Times Anticipated for SAE Type IV Fluid Mixtures as a Function of Weather Conditions and OAT

CAUTION: THIS TABLE IS FOR USE IN DEPARTURE PLANNING ONLY, AND IT SHOULD BE USED IN CONJUNCTION WITH PRE-TAKEOFF CHECK PROCEDURES.

OAT		SAE Type IV Fluid	Approximate Holdover Times under Various Weather Conditions (hours: minutes)						
°C	°F	Concentration Neat-Fluid/Water (Vol. %/Vol. %)	*Frost	Freezing Fog	Snow	***Freezing Drizzle	Light Freezing Rain	Rain on Cold Soaked Wing	Other‡
above 0	above 32	100/0	18:00	1:05-2:15	0:35-1:05	0:40-1:00	0:25-0:40	0:10-0:50	CAUTION: No holdover time guidelines exist
		75/25	6:00	1:05-1:45	0:20-0:40	0:30-1:00	0:15-0:30	0:05-0:35	
		50/50	4:00	0:20-0:35	0:05-0:20	0:10-0:20	0:05-0:10	CAUTION: Clear ice may require touch for confirmation	
0 to -3	32 to 27	100/0	12:00	1:05-2:15	0:30-0:55	0:40-1:00	0:25-0:40		
		75/25	5:00	1:05-1:45	0:20-0:35	0:30-1:00	0:15-0:30		
		50/50	3:00	0:20-0:35	0:05-0:15	0:10-0:20	0:05-0:10		
below -3 to -14	below 27 to 7	100/0	12:00	0:40-1:30	0:20-0:40	**0:20-0:55	**0:10-0:30		
		75/25	5:00	0:25-1:00	0:15-0:25	**0:20-0:55	**0:10-0:30		
below -14 to -25	below 7 to -13	100/0	12:00	0:20-0:40	0:15-0:30				
below -25	below -13	100/0	SAE Type IV fluid may be used below -25°C (-13°F) provided the freezing point of the fluid is at least 7°C(13°F) below the OAT and the aerodynamic acceptance criteria are met. Consider use of SAE Type I when SAE Type IV fluid cannot be used.						

°C	**Degrees Celsius**
°F	**Degrees Fahrenheit**
OAT	**Outside Air Temperature**
VOL	**Volume**

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER.

* During conditions that apply to aircraft protection for ACTIVE FROST

** No holdover time guidelines exist for this condition below -10 °C (14 °F)

*** Use light freezing rain holdover times if positive identification of freezing drizzle is not possible

‡ Snow pellets, snow grains, ice pellets, moderate and heavy freezing rain, hail

CAUTION: THE TIME OF PROTECTION WILL BE SHORTENED IN HEAVY WEATHER CONDITIONS. HEAVY PRECIPITATION RATES OR HIGH MOISTURE CONTENT, HIGH WIND VELOCITY OR JET BLAST MAY REDUCE HOLDOVER TIME BELOW THE LOWEST TIME STATED IN THE RANGE. HOLDOVER TIME MAY BE REDUCED WHEN AIRCRAFT SKIN TEMPERATURE IS LOWER THAN OAT.

CAUTION: SAE TYPE IV FLUID USED DURING GROUND DEICING/ANTI-ICING IS NOT INTENDED FOR AND DOES NOT PROVIDE PROTECTION DURING FLIGHT.

Effective: October1, 1999

TABLE 4A - Guideline for Holdover Times Anticipated for UCAR ULTRA+ Type IV Fluid Mixtures as a Function of Weather Conditions and OAT – *Viscosity of fluid tested 36,000cP, 0°C, 0.3RPM, Spindle SC4-31/13R, 10ml fluid, 10 min*

CAUTION: THIS TABLE IS FOR USE IN DEPARTURE PLANNING ONLY, AND IT SHOULD BE USED IN CONJUNCTION WITH PRE-TAKEOFF CHECK PROCEDURES.

OAT		SAE Type IV Fluid Concentration	Approximate Holdover Times under Various Weather Conditions (hours: minutes)						
°C	°F	Neat-Fluid/Water (Vol. %/Vol. %)	*Frost	Freezing Fog	Snow	***Freezing Drizzle	Light Freezing Rain	Rain on Cold Soaked Wing	Other‡
above 0	Above 32	100/0	18:00	1:35-3:35	0:40-1:25	0:45-1:35	0:25-0:40	0:10-1:20	CAUTION: No holdover time guidelines exist
		****75/25							
		****50/50						CAUTION: Clear ice may require touch for confirmation	
0 to -3	32 to 27	100/0	12:00	1:35-3:35	0:35-1:15	0:45-1:35	0:25-0:40		
		****75/25							
		****50/50							
below -3 to -14	below 27 to 7	100/0	12:00	1:25-3:00	0:25-0:55	**0:45-1:25	**0:30-0:45		
		****75/25							
below -14 to -25	below 7 to -13	100/0	12:00	0:40-2:10	0:20-0:45				
below -25	below -13	100/0	**UCAR ULTRA+** Type IV fluid may be used below -25°C (-13°F) provided the freezing point of the fluid is at least 7°C (13°F) below the OAT and the aerodynamic acceptance criteria are met. Consider use of SAE Type I when **UCAR ULTRA+** Type IV fluid cannot be used.						

C	**Degrees Celsius**
°F	**Degrees Fahrenheit**
OAT	**Outside Air Temperature**
VOL	**Volume**

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER.

* During conditions that apply to aircraft protection for ACTIVE FROST

** No holdover time guidelines exist for this condition below -10 °C (14 °F)

*** Use light freezing rain holdover times if positive identification of freezing drizzle is not possible

**** Holdover times for 50/50 and 75/25 mixtures are no longer valid

‡ Snow pellets, snow grains, ice pellets, moderate and heavy freezing rain, hail

CAUTION: THE TIME OF PROTECTION WILL BE SHORTENED IN HEAVY WEATHER CONDITIONS. HEAVY PRECIPITATION RATES OR HIGH MOISTURE CONTENT, HIGH WIND VELOCITY OR JET BLAST MAY REDUCE HOLDOVER TIME BELOW THE LOWEST TIME STATED IN THE RANGE. HOLDOVER TIME MAY BE REDUCED WHEN AIRCRAFT SKIN TEMPERATURE IS LOWER THAN OAT.

CAUTION: UCAR ULTRA+ TYPE IV FLUID USED DURING GROUND DEICING/ANTI-ICING IS NOT INTENDED FOR AND DOES NOT PROVIDE PROTECTION DURING FLIGHT.

Effective: October 1, 1999

TABLE 4B - Guideline for Holdover Times Anticipated for OCTAGON MAXFLIGHT Type IV Fluid Mixtures as a Function of Weather Conditions and OAT – ***Viscosity of Fluid Tested 2,920cP, 20°C, 0.3RPM, Spindle LV1, 600ml beaker,500ml fluid,33min 20sec, grd.leg***

CAUTION: THIS TABLE IS FOR USE IN DEPARTURE PLANNING ONLY, AND IT SHOULD BE USED IN CONJUNCTION WITH PRE-TAKEOFF CHECK PROCEDURES.

OAT		SAE Type IV Fluid Concentration	Approximate Holdover Times under Various Weather Conditions (hours: minutes)						
°C	°F	Neat-Fluid/Water (Vol. %/Vol. %)	*Frost	Freezing Fog	Snow	***Freezing Drizzle	Light Freezing Rain	Rain on Cold Soaked Wing	Other‡
above 0	Above 32	100/0	18:00	2:15-4:00	1:00-1:30	0:55-1:55	0:30-0:50	0:10-1:15	CAUTION: No holdover time guidelines exist
		75/25	6:00	1:30-2:50	0:40-1:30	0:50-1:20	0:20-0:40	0:05-0:40	
		50/50	4:00	0:30-0:50	0:15-0:35	0:15-0:25	0:05-0:15	CAUTION: Clear ice may require touch for confirmation	
0 to -3	32 to 27	100/0	12:00	2:15-4:00	0:50-1:20	0:55-1:55	0:30-0:50		
		75/25	5:00	1:30-2:50	0:30-1:00	0:50-1:20	0:20-0:40		
		50/50	3:00	0:30-0:50	0:15-0:30	0:15-0:25	0:05-0:15		
below -3 to -14	below 27 to 7	100/0	12:00	0:45-1:55	0:25-0:50	**0:25-1:10	**0:15-0:40		
		75/25	5:00	0:30-1:10	0:20-0:40	**0:20-1:00	**0:15-0:30		
below -14 to -25	below 7 to -13	100/0	12:00	0:20-0:40	0:20-0:40				
below -25	below -13	100/0	**OCTAGON MAXFLIGHT** Type IV fluid may be used below -25°C (-13°F) provided the freezing point of the fluid is at least 7°C (13°F) below the OAT and the aerodynamic acceptance criteria are met. Consider use of SAE Type I when **OCTAGON MAXFLIGHT** Type IV fluid cannot be used.						

°C	**Degrees Celsius**
°F	**Degrees Fahrenheit**
OAT	**Outside Air Temperature**
VOL	**Volume**

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER.

*	During conditions that apply to aircraft protection for ACTIVE FROST
**	No holdover time guidelines exist for this condition below -10 °C (14 °F)
***	Use light freezing rain holdover times if positive identification of freezing drizzle is not possible
‡	Snow pellets, snow grains, ice pellets, moderate and heavy freezing rain, hail

CAUTION: THE TIME OF PROTECTION WILL BE SHORTENED IN HEAVY WEATHER CONDITIONS. HEAVY PRECIPITATION RATES OR HIGH MOISTURE CONTENT, HIGH WIND VELOCITY OR JET BLAST MAY REDUCE HOLDOVER TIME BELOW THE LOWEST TIME STATED IN THE RANGE. HOLDOVER TIME MAY BE REDUCED WHEN AIRCRAFT SKIN TEMPERATURE IS LOWER THAN OAT.

CAUTION: **OCTAGON MAXFLIGHT** TYPE IV FLUID USED DURING GROUND DEICING/ANTI-ICING IS NOT INTENDED FOR AND DOES NOT PROVIDE PROTECTION DURING FLIGHT.

Effective: October 1, 1999

TABLE 4C - Guideline for Holdover Times Anticipated for KILFROST ABC-S Type IV Fluid Mixtures as a Function of Weather Conditions and OAT – *Viscosity of neat fluid tested - 17,000cP, 20°C, 0.3RPM, Spindle LV2, 250ml beaker, 150 ml fluid,10min., grd.leg.*

CAUTION: THIS TABLE IS FOR USE IN DEPARTURE PLANNING ONLY, AND IT SHOULD BE USED IN CONJUNCTION WITH PRE-TAKEOFF CHECK PROCEDURES.

OAT		SAE Type IV Fluid Concentration	Approximate Holdover Times under Various Weather Conditions (hours: minutes)						
°C	°F	Neat-Fluid/Water (Vol. %/Vol. %)	*Frost	Freezing Fog	Snow	***Freezing Drizzle	Light Freezing Rain	Rain on Cold Soaked Wing	Other‡
above 0	Above 32	100/0	18:00	2:35-4:00	1:10-2:00	1:20-1:50	1:00-1:25	0:20-1:15	CAUTION: No holdover time guidelines exist
		75/25	6:00	1:05-1:45	0:30-1:05	0:45-1:10	0:35-0:50	0:10-0:50	
		50/50	4:00	0:20-0:35	0:05-0:20	0:15-0:20	0:05-0:10	CAUTION: Clear ice may require touch for confirmation	
0 to -3	32 to 27	100/0	12:00	2:35-4:00	1:00-1:40	1:20-1:50	1:00-1:25		
		75/25	5:00	1:05-1:45	0:30-0:55	0:45-1:10	0:35-0:50		
		50/50	3:00	0:20-0:35	0:05-0:15	0:15-0:20	0:05-0:10		
below -3 to -14	below 27 to 7	100/0	12:00	0:45-2:05	0:45-1:20	**0:20-1:00	**0:10-0:30		
		75/25	5:00	0:25-1:00	0:25-0:50	**0:20-1:10	**0:10-0:35		
below -14 to -25	below 7 to -13	100/0	12:00	0:20-0:40	0:40-1:10				
below -25	below -13	100/0	**KILFROST ABC-S** Type IV fluid may be used below -25°C (-13°F) provided the freezing point of the fluid is at least 7°C (13°F) below the OAT and the aerodynamic acceptance criteria are met. Consider use of SAE Type I when **KILFROST ABC-S** Type IV fluid cannot be used.						

°C	**Degrees Celsius**
°F	**Degrees Fahrenheit**
OAT	**Outside Air Temperature**
VOL	**Volume**

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER.

* During conditions that apply to aircraft protection for ACTIVE FROST

** No holdover time guidelines exist for this condition below -10 °C (14 °F)

*** Use light freezing rain holdover times if positive identification of freezing drizzle is not possible

‡ Snow pellets, snow grains, ice pellets, moderate and heavy freezing rain, hail

CAUTION: THE TIME OF PROTECTION WILL BE SHORTENED IN HEAVY WEATHER CONDITIONS. HEAVY PRECIPITATION RATES OR HIGH MOISTURE CONTENT, HIGH WIND VELOCITY OR JET BLAST MAY REDUCE HOLDOVER TIME BELOW THE LOWEST TIME STATED IN THE RANGE. HOLDOVER TIME MAY BE REDUCED WHEN AIRCRAFT SKIN TEMPERATURE IS LOWER THAN OAT.

CAUTION: **KILFROST ABC-S** TYPE IV FLUID USED DURING GROUND DEICING/ANTI-ICING IS NOT INTENDED FOR AND DOES NOT PROVIDE PROTECTION DURING FLIGHT.

TABLE 4D - Guideline for Holdover Times Anticipated for SAFEWING MP IV 1957 Type IV Fluid Mixtures as a Function of Weather Conditions and OAT – ***Viscosity of Fluid Tested 16,200cP, 20°C, 0.3RPM, Spindle SC4-13R,10 ml fluid,15 min***

CAUTION: THIS TABLE IS FOR USE IN DEPARTURE PLANNING ONLY, AND IT SHOULD BE USED IN CONJUNCTION WITH PRE-TAKEOFF CHECK PROCEDURES.

OAT		SAE Type IV Fluid Concentration	Approximate Holdover Times under Various Weather Conditions (hours: minutes)						
°C	°F	Neat-Fluid/Water (Vol. %/Vol. %)	*Frost	Freezing Fog	Snow	***Freezing Drizzle	Light Freezing Rain	Rain on Cold Soaked Wing	Other‡
above 0	Above 32	100/0	18:00	1:05-2:15	0:35-1:05	0:40-1:10	0:30-0:45	0:15-1:10	CAUTION: No holdover time guidelines exist
		75/25	6:00	1:10-2:10	0:35-1:05	0:35-1:05	0:25-0:40	0:10-1:00	
		50/50	4:00	0:25-0:50	0:15-0:30	0:15-0:25	0:05-0:15	CAUTION: Clear ice may require touch for confirmation	
0 to -3	32 to 27	100/0	12:00	1:05-2:15	0:30-0:55	0:40-1:10	0:30-0:45		
		75/25	5:00	1:10-2:10	0:30-0:50	0:35-1:05	0:25-0:40		
		50/50	3:00	0:25-0:50	0:10-0:20	0:15-0:25	0:05-0:15		
below -3 to -14	below 27 to 7	100/0	12:00	0:45-1:30	0:30-0:50	**0:35-0:55	**0:20-0:35		
		75/25	5:00	0:25-1:10	0:20-0:40	**0:25-0:55	**0:15-0:30		
below -14 to -25	below 7 to -13	100/0	12:00	0:25-0:40	0:25-0:45				
below -25	below -13	100/0	**SAFEWING® MP IV 1957** Type IV fluid may be used below -25°C (-13°F) provided the freezing point of the fluid is at least 7°C (13°F) below the OAT and the aerodynamic acceptance criteria are met. Consider use of SAE Type I when **SAFEWING® MP IV 1957** Type IV fluid cannot be used.						

°C	**Degrees Celsius**
°F	**Degrees Fahrenheit**
OAT	**Outside Air Temperature**
VOL	**Volume**

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER.

*	During conditions that apply to aircraft protection for ACTIVE FROST
**	No holdover time guidelines exist for this condition below -10 °C (14 °F)
***	Use light freezing rain holdover times if positive identification of freezing drizzle is not possible
‡	Snow pellets, snow grains, ice pellets, moderate and heavy freezing rain, hail

CAUTION: THE TIME OF PROTECTION WILL BE SHORTENED IN HEAVY WEATHER CONDITIONS. HEAVY PRECIPITATION RATES OR HIGH MOISTURE CONTENT, HIGH WIND VELOCITY OR JET BLAST MAY REDUCE HOLDOVER TIME BELOW THE LOWEST TIME STATED IN THE RANGE. HOLDOVER TIME MAY BE REDUCED WHEN AIRCRAFT SKIN TEMPERATURE IS LOWER THAN OAT.

CAUTION: SAFEWING® MP IV 1957 TYPE IV FLUID USED DURING GROUND DEICING/ANTI-ICING IS NOT INTENDED FOR AND DOES NOT PROVIDE PROTECTION DURING FLIGHT.

Effective: October 1, 1999

TABLE 4E - Guideline for Holdover Times Anticipated for SAFEWING MP IV 2001 Type IV Fluid Mixtures as a Function of Weather Conditions and OAT – ***Viscosity of fluid tested 18,000cP 20°C, 0.3RPM, Spindle SC4-13R,10 ml fluid,15 min***

CAUTION: THIS TABLE IS FOR USE IN DEPARTURE PLANNING ONLY, AND IT SHOULD BE USED IN CONJUNCTION WITH PRE-TAKEOFF CHECK PROCEDURES.

OAT		SAE Type IV Fluid Concentration	Approximate Holdover Times under Various Weather Conditions (hours: minutes)						
°C	°F	Neat-Fluid/Water (Vol. %/Vol. %)	*Frost	Freezing Fog	Snow	***Freezing Drizzle	Light Freezing Rain	Rain on Cold Soaked Wing	Other‡
above 0	Above 32	100/0	18:00	1:05-2:15	1:55-2:00	0:55-1:55	0:40-1:00	0:15-1:55	CAUTION: No holdover time guidelines exist
		75/25	6:00	1:05-1:45	0:50-1:25	0:35-1:10	0:25-0:35	0:05-0:55	
		50/50	4:00	0:20-0:35	0:10-0:20	0:10-0:20	0:05-0:15	CAUTION: Clear ice may require touch for confirmation	
0 to -3	32 to 27	100/0	12:00	1:05-2:15	1:00-1:55	0:55-1:55	0:40-1:00		
		75/25	5:00	1:05-1:45	0:35-1:00	0:35-1:10	0:25-0:35		
		50/50	3:00	0:20-0:35	0:10-0:20	0:10-0:20	0:05-0:15		
below -3 to -14	below 27 to 7	100/0	12:00	0:40-1:30	0:30-0:50	**0:55-1:35	**0:30-0:45		
		75/25	5:00	0:25-1:00	0:20-0:35	**0:40-1:10	**0:20-0:30		
below -14 to -25	below 7 to -13	100/0	12:00	0:20-0:40	0:20-0:35				
below -25	below -13	100/0	**SAFEWING® MP IV 2001** Type IV fluid may be used below -25°C (-13°F) provided the freezing point of the fluid is at least 7°C (13°F) below the OAT and the aerodynamic acceptance criteria are met. Consider use of SAE Type I when **SAFEWING® MP IV 2001** Type IV fluid cannot be used.						

°C	**Degrees Celsius**
°F	**Degrees Fahrenheit**
OAT	**Outside Air Temperature**
VOL	**Volume**

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER.

* During conditions that apply to aircraft protection for ACTIVE FROST

** No holdover time guidelines exist for this condition below -10 °C (14 °F)

*** Use light freezing rain holdover times if positive identification of freezing drizzle is not possible

‡ Snow pellets, snow grains, ice pellets, moderate and heavy freezing rain, hail

CAUTION: THE TIME OF PROTECTION WILL BE SHORTENED IN HEAVY WEATHER CONDITIONS. HEAVY PRECIPITATION RATES OR HIGH MOISTURE CONTENT, HIGH WIND VELOCITY OR JET BLAST MAY REDUCE HOLDOVER TIME BELOW THE LOWEST TIME STATED IN THE RANGE. HOLDOVER TIME MAY BE REDUCED WHEN AIRCRAFT SKIN TEMPERATURE IS LOWER THAN OAT.

CAUTION: SAFEWING® MP IV 2001 TYPE IV FLUID USED DURING GROUND DEICING/ANTI-ICING IS NOT INTENDED FOR AND DOES NOT PROVIDE PROTECTION DURING FLIGHT.

TABLE 4F - Guideline for Holdover Times Anticipated for SPCA AD-480 Type IV Fluid Mixtures as a Function of Weather Conditions and OAT – ***Viscosity of fluid tested 21,200cP, 20°C, 0.3RPM, Spindle SC4-34/13R, 10ml fluid, 30min***

CAUTION: THIS TABLE IS FOR USE IN DEPARTURE PLANNING ONLY, AND IT SHOULD BE USED IN CONJUNCTION WITH PRE-TAKEOFF CHECK PROCEDURES.

OAT		SAE Type IV Fluid Concentration	Approximate Holdover Times under Various Weather Conditions (hours: minutes)						
°C	°F	Neat-Fluid/Water (Vol. %/Vol. %)	*Frost	Freezing Fog	Snow	***Freezing Drizzle	Light Freezing Rain	Rain on Cold Soaked Wing	Other‡
above 0	Above 32	100/0	18:00	1:05-2:15	1:10-2:00	1:05-2:00	0:50-1:10	0:15-0:55	CAUTION: No holdover time guidelines exist
		75/25	6:00	1:05-1:45	0:45-1:25	0:50-1:20	0:35-0:50	0:10-0:40	
		50/50	4:00	0:20-0:35	0:15-0:35	0:15-0:35	0:10-0:25		
0 to -3	32 to 27	100/0	12:00	1:05-2:15	1:05-1:50	1:05-2:00	0:50-1:10	CAUTION: Clear ice may require touch for confirmation	
		75/25	5:00	1:05-1:45	0:45-1:25	0:50-1:20	0:35-0:50		
		50/50	3:00	0:20-0:35	0:10-0:30	0:15-0:35	0:10-0:25		
below -3 to -14	below 27 to 7	100/0	12:00	0:40-1:30	0:30-0:55	**0:25-1:20	**0:20-0:40		
		75/25	5:00	0:25-1:00	0:25-0:45	**0:30-1:15	**0:20-0:35		
below -14 to -25	below 7 to -13	100/0	12:00	0:20-0:40	0:25-0:40				
below -25	below -13	100/0	**SPCA AD-480** Type IV fluid may be used below -25°C (-13°F) provided the freezing point of the fluid is at least 7°C (13°F) below the OAT and the aerodynamic acceptance criteria are met. Consider use of SAE Type I when **SPCA AD-480** Type IV fluid cannot be used.						

°C	**Degrees Celsius**
°F	**Degrees Fahrenheit**
OAT	**Outside Air Temperature**
VOL	**Volume**

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER.

*	During conditions that apply to aircraft protection for ACTIVE FROST
**	No holdover time guidelines exist for this condition below -10 °C (14 °F)
***	Use light freezing rain holdover times if positive identification of freezing drizzle is not possible
‡	Snow pellets, snow grains, ice pellets, moderate and heavy freezing rain, hail

CAUTION: THE TIME OF PROTECTION WILL BE SHORTENED IN HEAVY WEATHER CONDITIONS. HEAVY PRECIPITATION RATES OR HIGH MOISTURE CONTENT, HIGH WIND VELOCITY OR JET BLAST MAY REDUCE HOLDOVER TIME BELOW THE LOWEST TIME STATED IN THE RANGE. HOLDOVER TIME MAY BE REDUCED WHEN AIRCRAFT SKIN TEMPERATURE IS LOWER THAN OAT.

CAUTION: SPCA AD-480 TYPE IV FLUID USED DURING GROUND DEICING/ANTI-ICING IS NOT INTENDED FOR AND DOES NOT PROVIDE PROTECTION DURING FLIGHT.

TABLE 5 - Guidelines for the application of SAE Type II and Type IV fluid mixtures.
Minimum Concentrations as a Function of Outside Air Temperature(OAT)
Concentrations in % V/V

Outside Air Temperature OAT	One-step Procedure Deicing/anti-icing	Two-step Procedure	
		First step: Deicing	Second step: Anti-icing[1]
-3° C (27° F) and above	50/50 Heated[2] Type II/IV	Water heated or a heated mix of Type I, II or IV with water	50/50 Type II/IV
Below -3° C (27° F) to -14° C (7° F)	75/25 Heated[2] Type II/IV	Heated suitable mix of Type I, Type II/IV and water with FP not more than 3° C (5° F) above actual OAT	75/25 Type II/IV
Below -14° C (7° F) to -25° C (-13° F)	100/0 Heated[2] Type II/IV	Heated suitable mix of Type I, Type II/IV and water with FP not more than 3° C (5° F) above actual OAT	100/0 Type II/IV
Below -25° C (-13° F)	SAE Type II/IV fluid may be used below -25° C (-13° F) provided that the freezing point of the fluid is at least a 7° C (13° F) below OAT and that aerodynamic acceptance criteria are met. Consider the use of SAE Type I when Type II/IV fluid cannot be used (see table 1).		

NOTE: For heated fluids, a fluid temperature not less than 60° C (140° F) at the nozzle is desirable.
Upper temperature limit shall not exceed fluid and aircraft manufacturers recommendations.

CAUTION: Wing skin temperatures may differ and in some cases may be lower than OAT.
A stronger mix can be used under the latter conditions.

1) To be applied before first step fluid freezes, typically within 3 minutes.
2) Clean aircraft may be anti-iced with unheated fluid.

Caution: An insufficient amount of anti-icing fluid, especially in the second step of a two-step procedure may cause a substantial loss of holdover time, particularly when using a Type I fluid mixture for the first step (deicing).

Table 6. List of Qualified(1) Deicing/Anti-Icing Fluids – Winter 1999-2000

Qualified Type I Deicing/Anti-Icing Fluids

Company Name	Fluid Name
Clariant	Safewing DGI 1937
Clariant	Safewing MPI 1938
Home Oil Inc.	SafeTemp
Inland	Duragly – P
Kilfrost	Kilfrost DF PLUS
Kilfrost	Kilfrost DF
Lyondell Chemical Worldwide, Inc	ARCOPlus Concentrate
Lyondell Chemical Worldwide, Inc	ARCOPlus Dilute
Lyondell Chemical Worldwide, Inc	ARCOPlus Canadian Dilute
Octagon Process, Inc	Octaflo/Aerex 99
SPCA	SPCA DE-910
Union Carbide	UCAR® ADF Concentrate
Union Carbide	UCAR® ADF 50/50
Union Carbide	UCAR® XL 54

Qualified Type II Deicing/Anti-Icing Fluids

Company Name	Fluid Name
Clariant	Safewing MP II 1951
Kilfrost	Kilfrost ABC-II PLUS
Kilfrost	Kilfrost ABC-3
SPCA	SPCA AD-104/N

Qualified Type IV Deicing/Anti-Icing Fluids

Company Name	Fluid Name
Clariant	Safewing MP IV 1957
Clariant	Safewing MP IV 2001
Kilfrost	Kilfrost ABC-S
Octagon Process	Max Flight
SPCA	SPCA AD-480
Union Carbide	UCAR® ADF/AAF ULTRA+

(1) Qualified implies that the fluid has met the requirements of the applicable SAE AMS performance specifications as conducted by the Anti-Icing Materials International Laboratory at the University of Quebec at Chicoutimi, Canada, in effect at the time of certification; and has completed holdover time testing. Fluids that successfully qualify after the issuance of this list will appear in a later update.

TRANSPORT CANADA HOT TABLES

TABLE 1

SAE TYPE I FLUID HOLDOVER TABLE

Guideline for Holdover Times Anticipated for SAE Type I Fluid Mixture as a Function of Weather Conditions and OAT

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER

OAT		Approximate Holdover Times Under Various Weather Conditions (hours:minutes)						
°C	°F	Frost[1]	Freezing Fog	Moderate Snow	Freezing Drizzle[2]	Light Freezing Rain	Rain on Cold Soaked Wing	Other[3]
above 0°	above 32°	0:45	0:12 - 0:30	0:06 - 0:15	0:05 - 0:08	0:02 - 0:05	0:02 - 0:05	CAUTION : No holdover time guidelines exist
0 to -10	32 to 14	0:45	0:06 - 0:15	0:06 - 0:15	0:05 - 0:08	0:02 - 0:05		
below -10	below 14	0:45	0:06 - 0:15	0:06 - 0:15				

°C	**= Degrees Celsius**	**OAT**	**= Outside Air Temperature**
°F	**= Degrees Fahrenheit**	**FP**	**= Freezing Point**

NOTES

1 During conditions that apply to aircraft protection for ACTIVE FROST.

2 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.

3 Heavy snow, snow pellets, snow grains, ice pellets, moderate and heavy freezing rain, and hail.

SAE Type I Fluid / Water Mixture is selected so that the FP of the mixture is at least 10°C (18°F) below OAT.

CAUTIONS:

THE TIME OF PROTECTION WILL BE SHORTENED IN HEAVY WEATHER CONDITIONS, HEAVY PRECIPITATION RATES OR HIGH MOISTURE CONTENT. HIGH WIND VELOCITY OR JET BLAST MAY REDUCE HOLDOVER TIME BELOW THE LOWEST TIME STATED IN THE RANGE. HOLDOVER TIME MAY ALSO BE REDUCED WHEN AIRCRAFT SKIN TEMPERATURE IS LOWER THAN OAT.

THE ONLY ACCEPTABLE DECISION CRITERIA TIME IS THE SHORTEST TIME WITHIN THE APPLICABLE HOLDOVER TIME TABLE CELL.

FLUIDS USED DURING GROUND DEICING ARE NOT INTENDED FOR AND DO NOT PROVIDE ICE PROTECTION DURING FLIGHT.

TRANSPORT CANADA, AUGUST 1999

TABLE 2

SAE TYPE II FLUID HOLDOVER TABLE[1]

Guideline for Holdover Times Anticipated for Type II Fluid Concentrations as a Function of Weather Conditions and OAT

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER

OAT		Type II Fluid Concentration Neat Fluid/Water (Vol% / Vol%)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)						
°C	°F		Frost[2]	Freezing Fog	Moderate Snow	Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing	Other[5]
above 0°	above 32°	100/0	12:00	1:05 - 2:15	0:20 - 1:00	0:30 -1:00	0:15 - 0:30	0:05 - 0:40	
		75/25	6:00	0:50 - 1:45	0:15 - 0:40	0:20 -0:45	0:10 - 0:25	0:05 - 0:25	
		50/50	4:00	0:15 - 0:35	0:05 - 0:15	0:05 - 0:20	0:05 - 0:10		
0 to -3	32 to 27	100/0	8:00	0:35 - 1:30	0:20 - 0:45	0:30 - 1:00	0:15 - 0:30	CAUTION: No holdover time guidelines exist	
		75/25	5:00	0:25 - 1:00	0:15 - 0:30	0:20 - 0:45	0:10 - 0:25		
		50/50	3:00	0:15 - 0:35	0:05 - 0:15	0:05 - 0:20	0:05 - 0:10		
below -3 to -14	below 27 to 7	100/0	8:00	0:30 - 1:05	0:15 - 0:35	0:15 - 0:45[3]	0:10 - 0:30[3]		
		75/25	5:00	0:20 - 0:55	0:15 - 0:25	0:15 - 0:30[3]	0:10 - 0:20[3]		
below -14 to -25	below 7 to -13	100/0	8:00	0:15 - 0:20	0:15 - 0:30				
below -25	below -13	100/0	Type II fluid may be used below -25°C (-13°F) provided the freezing point of the fluid is at least 7°C (13°F) below the OAT and the aerodynamic acceptance criteria are met. Consider use of SAE Type I when Type II fluid cannot be used.						

°C = Degrees Celsius
°F = Degrees Fahrenheit
OAT = Outside Air Temperature
VOL = Volume

NOTES

1 Based on tests of neat fluids with the lowest viscosity deliverable on the aircraft, yet meeting Type II WSET and HHET.
2 During conditions that apply to aircraft protection for ACTIVE FROST.
3 The lowest use temperature is limited to -10°C (14°F).
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 Heavy snow, snow pellets, snow grains, ice pellets, moderate and heavy freezing rain, and hail.

CAUTIONS:

THE TIME OF PROTECTION WILL BE SHORTENED IN HEAVY WEATHER CONDITIONS, HEAVY PRECIPITATION RATES OR HIGH MOISTURE CONTENT. HIGH WIND VELOCITY OR JET BLAST MAY REDUCE HOLDOVER TIME BELOW THE LOWEST TIME STATED IN THE RANGE. HOLDOVER TIME MAY ALSO BE REDUCED WHEN AIRCRAFT SKIN TEMPERATURE IS LOWER THAN OAT.
THE ONLY ACCEPTABLE DECISION CRITERIA TIME IS THE SHORTEST TIME WITHIN THE APPLICABLE HOLDOVER TIME TABLE CELL.

FLUIDS USED DURING GROUND DEICING ARE NOT INTENDED FOR AND DO NOT PROVIDE ICE PROTECTION DURING FLIGHT.

TRANSPORT CANADA, AUGUST 1999

TABLE 2 K

KILFROST TYPE II FLUID HOLDOVER TABLE

ABC-II PLUS (3,600 mPa.s viscosity)[1]

Guideline for Holdover Times Anticipated for Type II Fluid Concentrations as a Function of Weather Conditions and OAT

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER

OAT		Type II Fluid Concentration Neat Fluid/Water (Vol% / Vol%)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)						
°C	°F		Frost[2]	Freezing Fog	Moderate Snow	Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing	Other[5]
above 0°	above 32°	100/0	12:00	1:10 - 2:25	0:35 - 1:20	0:35 - 1:10	0:30 - 0:40	0:05 - 1:00	CAUTION: No holdover time guidelines exist
		75/25	6:00	1:10 - 2:25	0:35 - 1:10	0:30 - 1:00	0:20 - 0:40	0:05 - 0:50	
		50/50	4:00	0:15 - 0:45	0:20 - 0:40	0:05 - 0:25	0:05 - 0:15		
0 to -3	32 to 27	100/0	8:00	1:10 - 2:25	0:25 - 0:55	0:35 - 1:10	0:30 - 0:40		
		75/25	5:00	1:10 - 2:25	0:25 - 0:50	0:30 - 1:00	0:20 - 0:40		
		50/50	3:00	0:15 - 0:45	0:15 - 0:35	0:05 - 0:25	0:05 - 0:15		
below -3 to -14	below 27 to 7	100/0	8:00	0:30 - 1:05	0:15 - 0:35	0:15 - 0:45[3]	0:10 - 0:30[3]		
		75/25	5:00	0:20 - 0:55	0:15 - 0:35	0:15 - 0:30[3]	0:10 - 0:20[3]		
below -14 to -25	below 7 to -13	100/0	8:00	0:15 - 0:20	0:15 - 0:30				
below -25	below -13	100/0	Type II fluid may be used below -25°C (-13°F) provided the freezing point of the fluid is at least 7°C (13°F) below the OAT and the aerodynamic acceptance criteria are met. Consider use of SAE Type I when Type II fluid cannot be used.						

°C = Degrees Celsius

°F = Degrees Fahrenheit

OAT = Outside Air Temperature

VOL = Volume

NOTES

1 Lowest on-wing viscosity – Brookfield Spindle LV2 with guard leg, 150ml of neat fluid, at 20°C, 0.3rpm, 10 minutes 0 seconds.

2 During conditions that apply to aircraft protection for ACTIVE FROST.

3 The lowest use temperature is limited to -10°C (14°F).

4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.

5 Heavy snow, snow pellets, snow grains, ice pellets, moderate and heavy freezing rain, and hail.

CAUTIONS:

THE TIME OF PROTECTION WILL BE SHORTENED IN HEAVY WEATHER CONDITIONS, HEAVY PRECIPITATION RATES OR HIGH MOISTURE CONTENT. HIGH WIND VELOCITY OR JET BLAST MAY REDUCE HOLDOVER TIME BELOW THE LOWEST TIME STATED IN THE RANGE. HOLDOVER TIME MAY ALSO BE REDUCED WHEN AIRCRAFT SKIN TEMPERATURE IS LOWER THAN OAT.

THE ONLY ACCEPTABLE DECISION CRITERIA TIME IS THE SHORTEST TIME WITHIN THE APPLICABLE HOLDOVER TIME TABLE CELL.

FLUIDS USED DURING GROUND DEICING ARE NOT INTENDED FOR AND DO NOT PROVIDE ICE PROTECTION DURING FLIGHT.

TRANSPORT CANADA, AUGUST 1999

TABLE 3

SAE TYPE III FLUID HOLDOVER TABLE

Guideline for Holdover Times Anticipated for SAE Type III Fluid Mixture as a Function of Weather Conditions and OAT

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER

OAT		Approximate Holdover Times Under Various Weather Conditions (hours:minutes)						
°C	**°F**	**Frost[1]**	**Freezing Fog**	**Moderate Snow**	**Freezing Drizzle[2]**	**Light Freezing Rain**	**Rain on Cold Soaked Wing**	**Other[3]**
above 0°	above 32°	5:00	0:50 - 1:30	0:15 - 0:30	0:25 - 0:50	0:15 - 0:25	0:05 - 0:35	
0 to -3	32 to 27	4:00	0:50 - 1:30	0:15 - 0:25	0:25 - 0:50	0:15 - 0:25	CAUTION: No holdover time guidelines exist	
below -3 to -14	below 27 to 7	4:00	0:50 - 1:30	0:10 - 0:20	0:25 - 0:50	0:15 - 0:25		
below -14	below 7	SAE Type III fluid may be used below -14°C (7°F) provided the freezing point of the fluid is at least 7°C (13°F) below the OAT and the aerodynamic acceptance criteria are met. Consider use of SAE Type I when SAE Type III fluid cannot be used.						

°C = Degrees Celsius

°F = Degrees Fahrenheit

OAT = Outside Air Temperature

FP = Freezing Point

NOTES

1 During conditions that apply to aircraft protection for ACTIVE FROST.

2 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.

3 Heavy snow, snow pellets, snow grains, ice pellets, moderate and heavy freezing rain, and hail.

CAUTIONS:

THE TIME OF PROTECTION WILL BE SHORTENED IN HEAVY WEATHER CONDITIONS, HEAVY PRECIPITATION RATES OR HIGH MOISTURE CONTENT. HIGH WIND VELOCITY OR JET BLAST MAY REDUCE HOLDOVER TIME BELOW THE LOWEST TIME STATED IN THE RANGE. HOLDOVER TIME MAY ALSO BE REDUCED WHEN AIRCRAFT SKIN TEMPERATURE IS LOWER THAN OAT.

THE ONLY ACCEPTABLE DECISION CRITERIA TIME IS THE SHORTEST TIME WITHIN THE APPLICABLE HOLDOVER TIME TABLE CELL.

FLUIDS USED DURING GROUND DEICING ARE NOT INTENDED FOR AND DO NOT PROVIDE ICE PROTECTION DURING FLIGHT.

TRANSPORT CANADA, AUGUST 1999

TABLE 4

SAE TYPE IV COMPOSITE FLUID HOLDOVER TABLE[1]

Guideline for Holdover Times Anticipated for Type IV Fluid Concentrations as a Function of Weather Conditions and OAT

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER

OAT		Type IV Fluid Concentration Neat Fluid/Water (Vol% / Vol%)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)						
°C	°F		Frost[2]	Freezing Fog	Moderate Snow	Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing	Other[5]
above 0°	above 32°	100/0	18:00	1:05 - 2:15	0:35 - 1:05	0:40 - 1:00	0:25 - 0:40	0:10 - 0:50	CAUTION: No holdover time guidelines exist
		75/25	6:00	1:05 - 1:45	0:20 - 0:40	0:30 - 1:00	0:15 - 0:30	0:05 - 0:35	
		50/50	4:00	0:20 - 0:35	0:05 - 0:20	0:10 - 0:20	0:05 - 0:10		
0 to -3	32 to 27	100/0	12:00	1:05 - 2:15	0:30 - 0:55	0:40 - 1:00	0:25 - 0:40		
		75/25	5:00	1:05 - 1:45	0:20 - 0:35	0:30 - 1:00	0:15 - 0:30		
		50/50	3:00	0:20 - 0:35	0:05 - 0:15	0:10 - 0:20	0:05 - 0:10		
below -3 to -14	below 27 to 7	100/0	12:00	0:40 - 1:30	0:20- 0:40	0:20 - 0:55[3]	0:10 - 0:30[3]		
		75/25	5:00	0:25 - 1:00	0:15 - 0:25	0:20 - 0:55[3]	0:10 - 0:30[3]		
below -14 to -25	below 7 to -13	100/0	12:00	0:20 - 0:40	0:15 - 0:30				
below -25	below -13	100/0	Type IV fluid may be used below -25°C (-13°F) provided the freezing point of the fluid is at least 7°C (13°F) below the OAT and the aerodynamic acceptance criteria are met. Consider use of SAE Type I when Type IV fluid cannot be used.						

°C = Degrees Celsius
°F = Degrees Fahrenheit
OAT = Outside Air Temperature
VOL = Volume

NOTES

1 Based on tests of neat fluids with the lowest viscosity deliverable on the aircraft, yet meeting Type IV WSET and HHET.
2 During conditions that apply to aircraft protection for ACTIVE FROST.
3 The lowest use temperature is limited to -10°C (14°F).
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 Heavy snow, snow pellets, snow grains, ice pellets, moderate and heavy freezing rain, and hail.

CAUTIONS:

THE TIME OF PROTECTION WILL BE SHORTENED IN HEAVY WEATHER CONDITIONS, HEAVY PRECIPITATION RATES OR HIGH MOISTURE CONTENT. HIGH WIND VELOCITY OR JET BLAST MAY REDUCE HOLDOVER TIME BELOW THE LOWEST TIME STATED IN THE RANGE. HOLDOVER TIME MAY ALSO BE REDUCED WHEN AIRCRAFT SKIN TEMPERATURE IS LOWER THAN OAT.
THE ONLY ACCEPTABLE DECISION CRITERIA TIME IS THE SHORTEST TIME WITHIN THE APPLICABLE HOLDOVER TIME TABLE CELL.

FLUIDS USED DURING GROUND DEICING ARE NOT INTENDED FOR AND DO NOT PROVIDE ICE PROTECTION DURING FLIGHT.

TRANSPORT CANADA, AUGUST 1999

TABLE 4 C1

CLARIANT TYPE IV FLUID HOLDOVER TABLE

SAFEWING MPIV 1957 (16,200 mPa.s viscosity)[1]

Guideline for Holdover Times Anticipated for Type IV Fluid Concentrations as a Function of Weather Conditions and OAT

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER

OAT		Type IV Fluid Concentration Neat Fluid/Water (Vol% / Vol%)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)						
°C	°F		Frost[2]	Freezing Fog	Moderate Snow	Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing	Other[5]
above 0°	above 32°	100/0	18:00	1:05 - 2:15	0:35 - 1:05	0:40 - 1:10	0:30 - 0:45	0:15 - 1:10	CAUTION: No holdover time guidelines exist
		75/25	6:00	1:10 - 2:10	0:35 - 1:05	0:35 - 1:05	0:25 - 0:40	0:10 - 1:00	
		50/50	4:00	0:25 - 0:50	0:15 - 0:30	0:15 - 0:25	0:05 - 0:15		
0 to -3	32 to 27	100/0	12:00	1:05 - 2:15	0:30 - 0:55	0:40 - 1:10	0:30 - 0:45		
		75/25	5:00	1:10 - 2:10	0:30 - 0:50	0:35 - 1:05	0:25 - 0:40		
		50/50	3:00	0:25 - 0:50	0:10 - 0:20	0:15 - 0:25	0:05 - 0:15		
below -3 to -14	below 27 to 7	100/0	12:00	0:45 - 1:30	0:30 - 0:50	0:35 - 0:55[3]	0:20 -0:35[3]		
		75/25	5:00	0:25 - 1:10	0:20 - 0:40	0:25 - 0:55[3]	0:15 - 0:30[3]		
below -14 to -25	below 7 to -13	100/0	12:00	0:25 - 0:40	0:25 - 0:45				
below -25	below -13	100/0	Type IV fluid may be used below -25°C (-13°F) provided the freezing point of the fluid is at least 7°C (13°F) below the OAT and the aerodynamic acceptance criteria are met. Consider use of SAE Type I when Type IV fluid cannot be used.						

°C = Degrees Celsius

°F = Degrees Fahrenheit

OAT = Outside Air Temperature

VOL = Volume

NOTES

1 Lowest on-wing viscosity – Brookfield Spindle SC4-34/13R, small sample adapter, at 20°C, 0.3rpm, for 15 minutes 0 seconds.

2 During conditions that apply to aircraft protection for ACTIVE FROST.

3 The lowest use temperature is limited to -10°C (14°F).

4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.

5 Heavy snow, snow pellets, snow grains, ice pellets, moderate and heavy freezing rain, and hail.

CAUTIONS:

THE TIME OF PROTECTION WILL BE SHORTENED IN HEAVY WEATHER CONDITIONS, HEAVY PRECIPITATION RATES OR HIGH MOISTURE CONTENT. HIGH WIND VELOCITY OR JET BLAST MAY REDUCE HOLDOVER TIME BELOW THE LOWEST TIME STATED IN THE RANGE. HOLDOVER TIME MAY ALSO BE REDUCED WHEN AIRCRAFT SKIN TEMPERATURE IS LOWER THAN OAT.

THE ONLY ACCEPTABLE DECISION CRITERIA TIME IS THE SHORTEST TIME WITHIN THE APPLICABLE HOLDOVER TIME TABLE CELL.

FLUIDS USED DURING GROUND DEICING ARE NOT INTENDED FOR AND DO NOT PROVIDE ICE PROTECTION DURING FLIGHT.

TRANSPORT CANADA, AUGUST 1999

TABLE 4 C2

CLARIANT TYPE IV FLUID HOLDOVER TABLE

SAFEWING MPIV 2001 (Viscosity 18,000 mPa.s)[1]

Guideline for Holdover Times Anticipated for Type IV Fluid Concentrations as a Function of Weather Conditions and OAT

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER

OAT		Type IV Fluid Concentration Neat Fluid/Water (Vol% / Vol%)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)						
°C	°F		Frost[2]	Freezing Fog	Moderate Snow	Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing	Other[5]
above 0°	above 32°	100/0	18:00	1:05 - 2:15	1:55 - 2:00	0:55 - 1:55	0:40 - 1:00	0:15 - 1:55	CAUTION: No holdover time guidelines exist
		75/25	6:00	1:05 - 1:45	0:50 - 1:25	0:35 - 1:10	0:25 - 0:35	0:05 - 0:55	
		50/50	4:00	0:20 - 0:35	0:10 - 0:20	0:10 - 0:20	0:05 - 0:15		
0 to -3	32 to 27	100/0	12:00	1:05 - 2:15	1:00 - 1:55	0:55 - 1:55	0:40 - 1:00		
		75/25	5:00	1:05 - 1:45	0:35 - 1:00	0:35 - 1:10	0:25 - 0:35		
		50/50	3:00	0:20 - 0:35	0:10 - 0:20	0:10 - 0:20	0:05 - 0:15		
below -3 to -14	below 27 to 7	100/0	12:00	0:40 - 1:30	0:30 - 0:50	0:55 - 1:35[3]	0:30 -0:45[3]		
		75/25	5:00	0:25 - 1:00	0:20 - 0:35	0:40 - 1:10[3]	0:20 - 0:30[3]		
below -14 to -25	below 7 to -13	100/0	12:00	0:20 - 0:40	0:20 - 0:35				
below -25	below -13	100/0	Type IV fluid may be used below -25°C (-13°F) provided the freezing point of the fluid is at least 7°C (13°F) below the OAT and the aerodynamic acceptance criteria are met. Consider use of SAE Type I when Type IV fluid cannot be used.						

°C = Degrees Celsius

°F = Degrees Fahrenheit

OAT = Outside Air Temperature

VOL = Volume

NOTES

1 Lowest on-wing viscosity – Brookfield Spindle SC4-34/13R, small sample adapter, 10 ml fluid, at 20°C, 0.3rpm, for 15 minutes 0 seconds.

2 During conditions that apply to aircraft protection for ACTIVE FROST.

3 The lowest use temperature is limited to -10°C (14°F).

4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.

5 Heavy snow, snow pellets, snow grains, ice pellets, moderate and heavy freezing rain, and hail.

CAUTIONS:

THE TIME OF PROTECTION WILL BE SHORTENED IN HEAVY WEATHER CONDITIONS, HEAVY PRECIPITATION RATES OR HIGH MOISTURE CONTENT. HIGH WIND VELOCITY OR JET BLAST MAY REDUCE HOLDOVER TIME BELOW THE LOWEST TIME STATED IN THE RANGE. HOLDOVER TIME MAY ALSO BE REDUCED WHEN AIRCRAFT SKIN TEMPERATURE IS LOWER THAN OAT.

THE ONLY ACCEPTABLE DECISION CRITERIA TIME IS THE SHORTEST TIME WITHIN THE APPLICABLE HOLDOVER TIME TABLE CELL.

FLUIDS USED DURING GROUND DEICING ARE NOT INTENDED FOR AND DO NOT PROVIDE ICE PROTECTION DURING FLIGHT.

TRANSPORT CANADA, AUGUST 1999

TABLE 4 K

KILFROST TYPE IV FLUID HOLDOVER TABLE

ABC-S (17,000 mPa.s viscosity)[1]

Guideline for Holdover Times Anticipated for Type IV Fluid Concentrations as a Function of Weather Conditions and OAT

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER

OAT		Type IV Fluid Concentration Neat Fluid/Water (Vol% / Vol%)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)						
°C	°F		Frost[2]	Freezing Fog	Moderate Snow	Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing	Other[5]
above 0°	above 32°	100/0	18:00	2:35 - 4:00	1:10 - 2:00	1:20 - 1:50	1:00 - 1:25	0:20 - 1:15	CAUTION: No holdover time guidelines exist
		75/25	6:00	1:05 - 1:45	0:30 - 1:05	0:45 - 1:10	0:35 - 0:50	0:10 - 0:50	
		50/50	4:00	0:20 - 0:35	0:05 - 0:20	0:15 - 0:20	0:05 - 0:10		
0 to -3	32 to 27	100/0	12:00	2:35 - 4:00	1:00 - 1:40	1:20 - 1:50	1:00 - 1:25		
		75/25	5:00	1:05 - 1:45	0:30 - 0:55	0:45 - 1:10	0:35 - 0:50		
		50/50	3:00	0:20 - 0:35	0:05 - 0:15	0:15 - 0:20	0:05 - 0:10		
below -3 to -14	below 27 to 7	100/0	12:00	0:45 - 2:05	0:45 - 1:20	0:20 - 1:00[3]	0:10 - 0:30[3]		
		75/25	5:00	0:25 - 1:00	0:25 - 0:50	0:20 - 1:10[3]	0:10 - 0:35[3]		
below -14 to -25	below 7 to -13	100/0	12:00	0:20 - 0:40	0:40 - 1:10				
below -25	below -13	100/0	Type IV fluid may be used below -25°C (-13°F) provided the freezing point of the fluid is at least 7°C (13°F) below the OAT and the aerodynamic acceptance criteria are met. Consider use of SAE Type I when Type IV fluid cannot be used.						

°C = Degrees Celsius
°F = Degrees Fahrenheit
OAT = Outside Air Temperature
VOL = Volume

NOTES

1 Lowest on-wing viscosity – Brookfield Spindle LV2 with guard leg, 150ml of neat fluid, at 20°C, 0.3 rpm, for 10 minutes 0 seconds.
2 During conditions that apply to aircraft protection for ACTIVE FROST.
3 The lowest use temperature is limited to -10°C (14°F).
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 Heavy snow, snow pellets, snow grains, ice pellets, moderate and heavy freezing rain, and hail.

CAUTIONS:

THE TIME OF PROTECTION WILL BE SHORTENED IN HEAVY WEATHER CONDITIONS, HEAVY PRECIPITATION RATES OR HIGH MOISTURE CONTENT. HIGH WIND VELOCITY OR JET BLAST MAY REDUCE HOLDOVER TIME BELOW THE LOWEST TIME STATED IN THE RANGE. HOLDOVER TIME MAY ALSO BE REDUCED WHEN AIRCRAFT SKIN TEMPERATURE IS LOWER THAN OAT.

THE ONLY ACCEPTABLE DECISION CRITERIA TIME IS THE SHORTEST TIME WITHIN THE APPLICABLE HOLDOVER TIME TABLE CELL.

FLUIDS USED DURING GROUND DEICING ARE NOT INTENDED FOR AND DO NOT PROVIDE ICE PROTECTION DURING FLIGHT.

TRANSPORT CANADA, AUGUST 1999

TABLE 4 O

OCTAGON TYPE IV FLUID HOLDOVER TABLE
MAX-FLIGHT (2,920 mPa.s viscosity)[1]

Guideline for Holdover Times Anticipated for Type IV Fluid Concentrations as a Function of Weather Conditions and OAT

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER

OAT		Type IV Fluid Concentration Neat Fluid/Water (Vol% / Vol%)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)						
°C	°F		Frost[2]	Freezing Fog	Moderate Snow	Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing	Other[5]
above 0°	above 32°	100/0	18:00	2:15 - 4:00	1:00 - 1:30	0:55 - 1:55	0:30 - 0:50	0:10 - 1:15	CAUTION: No holdover time guidelines exist
		75/25	6:00	1:30 - 2:50	0:40 - 1:30	0:50 - 1:20	0:20 - 0:40	0:05 - 0:40	
		50/50	4:00	0:30 - 0:50	0:15 - 0:35	0:15 - 0:25	0:05 - 0:15		
0 to -3	32 to 27	100/0	12:00	2:15 - 4:00	0:50 - 1:20	0:55 - 1:55	0:30 - 0:50		
		75/25	5:00	1:30 - 2:50	0:30 - 1:00	0:50 - 1:20	0:20 - 0:40		
		50/50	3:00	0:30 - 0:50	0:15 - 0:30	0:15 - 0:25	0:05 - 0:15		
below -3 to -14	below 27 to 7	100/0	12:00	0:45 - 1:55	0:25 - 0:50	0:25 - 1:10[3]	0:15 - 0:40[3]		
		75/25	5:00	0:30 - 1:10	0:20 - 0:40	0:20 - 1:00[3]	0:15 - 0:30[3]		
below -14 to -25	below 7 to -13	100/0	12:00	0:20 - 0:40	0:20 - 0:40				
below -25	below -13	100/0	Type IV fluid may be used below -25°C (-13°F) provided the freezing point of the fluid is at least 7°C (13°F) below the OAT and the aerodynamic acceptance criteria are met. Consider use of SAE Type I when Type IV fluid cannot be used.						

°C = Degrees Celsius

°F = Degrees Fahrenheit

OAT = Outside Air Temperature

VOL = Volume

NOTES

1 Lowest on-wing viscosity – Brookfield Spindle LV1 with guard leg, 500ml of neat fluid, at 20°C, 0.3rpm, 33 minutes 20 seconds.

2 During conditions that apply to aircraft protection for ACTIVE FROST.

3 The lowest use temperature is limited to -10°C (14°F).

4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.

5 Heavy snow, snow pellets, snow grains, ice pellets, moderate and heavy freezing rain, and hail.

CAUTIONS:

THE TIME OF PROTECTION WILL BE SHORTENED IN HEAVY WEATHER CONDITIONS, HEAVY PRECIPITATION RATES OR HIGH MOISTURE CONTENT. HIGH WIND VELOCITY OR JET BLAST MAY REDUCE HOLDOVER TIME BELOW THE LOWEST TIME STATED IN THE RANGE. HOLDOVER TIME MAY ALSO BE REDUCED WHEN AIRCRAFT SKIN TEMPERATURE IS LOWER THAN OAT.

THE ONLY ACCEPTABLE DECISION CRITERIA TIME IS THE SHORTEST TIME WITHIN THE APPLICABLE HOLDOVER TIME TABLE CELL.

FLUIDS USED DURING GROUND DEICING ARE NOT INTENDED FOR AND DO NOT PROVIDE ICE PROTECTION DURING FLIGHT.

TRANSPORT CANADA, AUGUST 1999

TABLE 4 S

SPCA TYPE IV FLUID HOLDOVER TABLE

AD-480 (21,200 mPa.s viscosity)[1]

Guideline for Holdover Times Anticipated for Type IV Fluid Concentrations as a Function of Weather Conditions and OAT

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER

OAT		Type IV Fluid Concentration Neat Fluid/Water (Vol% / Vol%)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)						
°C	°F		Frost[2]	Freezing Fog	Moderate Snow	Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing	Other[5]
above 0°	above 32°	100/0	18:00	1:05 - 2:15	1:10 - 2:00	1:05- 2:00	0:50 - 1:10	0:15 - 0:55	CAUTION: No holdover time guidelines exist
		75/25	6:00	1:05 - 1:45	0:45 - 1:25	0:50 - 1:20	0:35 - 0:50	0:10 - 0:40	
		50/50	4:00	0:20 - 0:35	0:15 - 0:35	0:15 - 0:35	0:10 - 0:25		
0 to -3	32 to 27	100/0	12:00	1:05 - 2:15	1:05 - 1:50	1:05- 2:00	0:50 - 1:10		
		75/25	5:00	1:05 - 1:45	0:45 - 1:25	0:50 - 1:20	0:35 - 0:50		
		50/50	3:00	0:20 - 0:35	0:10 - 0:30	0:15 - 0:35	0:10 - 0:25		
below -3 to -14	below 27 to 7	100/0	12:00	0:40- 1:30	0:30 - 0:55	0:25 - 1:20[3]	0:20 -0:40[3]		
		75/25	5:00	0:25 - 1:00	0:25 - 0:45	0:30 - 1:15[3]	0:20 - 0:35[3]		
below -14 to -25	below 7 to -13	100/0	12:00	0:20 - 0:40	0:25 - 0:40				
below -25	below -13	100/0	Type IV fluid may be used below -25°C (-13°F) provided the freezing point of the fluid is at least 7°C (13°F) below the OAT and the aerodynamic acceptance criteria are met. Consider use of SAE Type I when Type IV fluid cannot be used.						

°C = Degrees Celsius
°F = Degrees Fahrenheit
OAT = Outside Air Temperature
VOL = Volume

NOTES

1 Lowest on-wing viscosity – Brookfield Spindle SC4-34/13R, small sample adapter, at 20°C , 0.3 rpm, for 30 minutes 0 seconds.
2 During conditions that apply to aircraft protection for ACTIVE FROST.
3 The lowest use temperature is limited to -10°C (14°F).
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 Heavy snow, snow pellets, snow grains, ice pellets, moderate and heavy freezing rain, and hail.

CAUTIONS:

THE TIME OF PROTECTION WILL BE SHORTENED IN HEAVY WEATHER CONDITIONS, HEAVY PRECIPITATION RATES OR HIGH MOISTURE CONTENT. HIGH WIND VELOCITY OR JET BLAST MAY REDUCE HOLDOVER TIME BELOW THE LOWEST TIME STATED IN THE RANGE. HOLDOVER TIME MAY ALSO BE REDUCED WHEN AIRCRAFT SKIN TEMPERATURE IS LOWER THAN OAT.
THE ONLY ACCEPTABLE DECISION CRITERIA TIME IS THE SHORTEST TIME WITHIN THE APPLICABLE HOLDOVER TIME TABLE CELL.

FLUIDS USED DURING GROUND DEICING ARE NOT INTENDED FOR AND DO NOT PROVIDE ICE PROTECTION DURING FLIGHT.

TRANSPORT CANADA, AUGUST 1999

TABLE 4 U

UNION CARBIDE TYPE IV FLUID HOLDOVER TABLE

ULTRA+ (36,000 mPa.s viscosity)[1]

Guideline for Holdover Times Anticipated for Type IV Fluid Concentrations as a Function of Weather Conditions and OAT

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER

OAT		Type IV Fluid Concentration Neat Fluid/Water (Vol% / Vol%)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)						
°C	°F		Frost[2]	Freezing Fog	Moderate Snow	Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing	Other[5]
above 0°	above 32°	100/0	18:00	1:35 - 3:35	0:40 - 1:25	0:45- 1:35	0:25 - 0:40	0:10 - 1:20	CAUTION: No holdover time guidelines exist
		75/25							
		50/50							
0 to -3	32 to 27	100/0	12:00	1:35 - 3:35	0:35 - 1:15	0:45- 1:35	0:25 - 0:40		
		75/25							
		50/50							
below -3 to -14	below 27 to 7	100/0	12:00	1:25- 3:00	0:25 - 0:55	0:45 - 1:25[3]	0:30 -0:45[3]		
		75/25							
below -14 to -25	below 7 to -13	100/0	12:00	0:40 - 2:10	0:20 - 0:45				
below -25	below -13	100/0	Type IV fluid may be used below -25°C (-13°F) provided the freezing point of the fluid is at least 7°C (13°F) below the OAT and the aerodynamic acceptance criteria are met. Consider use of SAE Type I when Type IV fluid cannot be used.						

°C = Degrees Celsius

°F = Degrees Fahrenheit

OAT = Outside Air Temperature

VOL = Volume

NOTES

1 Lowest on-wing viscosity – Brookfield Spindle SC4-31/13R, small sample adapter, at 0°C, 0.3 rpm, for 10 minutes 0 seconds.
2 During conditions that apply to aircraft protection for ACTIVE FROST.
3 The lowest use temperature is limited to -10°C (14°F).
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 Heavy snow, snow pellets, snow grains, ice pellets, moderate and heavy freezing rain, and hail.

CAUTIONS:

THE TIME OF PROTECTION WILL BE SHORTENED IN HEAVY WEATHER CONDITIONS, HEAVY PRECIPITATION RATES OR HIGH MOISTURE CONTENT. HIGH WIND VELOCITY OR JET BLAST MAY REDUCE HOLDOVER TIME BELOW THE LOWEST TIME STATED IN THE RANGE. HOLDOVER TIME MAY ALSO BE REDUCED WHEN AIRCRAFT SKIN TEMPERATURE IS LOWER THAN OAT.

THE ONLY ACCEPTABLE DECISION CRITERIA TIME IS THE SHORTEST TIME WITHIN THE APPLICABLE HOLDOVER TIME TABLE CELL.

FLUIDS USED DURING GROUND DEICING ARE NOT INTENDED FOR AND DO NOT PROVIDE ICE PROTECTION DURING FLIGHT.

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TABLE 5

CURRENTLY QUALIFIED FLUIDS[†]

Table 5-1: Qualified Type I De-Icing Fluids

COMPANY NAME	FLUID NAME
ARCO/Lyondell Chemical	Arcoplus™
Clariant	Safewing DG I 1937
Clariant	Safewing MP I 1938
Home Oil	SafeTemp
Inland	Duragly-E
Inland	Duragly-P
Kilfrost	Kilfrost DF PLUS
Octagon Process	Octaflo™ EF/ Aerex 2000
Octagon Process	Octaflo™ / Aerex 99
SPCA	SPCA DE-910
Union Carbide	UCAR® ADF XL 54

Table 5-2: Qualified Type II Anti-Icing Fluids

COMPANY NAME	FLUID NAME
Clariant	Safewing MP II 1951
Kilfrost	Kilfrost ABC-3
Octagon Process	Octagon Forty Below™
SPCA	SPCA AD-104/N
Kilfrost	Kilfrost ABC-2 PLUS

Table 5-3: Qualified Type III Anti-Icing Fluids

COMPANY NAME	FLUID NAME

Table-5-4: Qualified Type IV Anti-Icing Fluids

COMPANY NAME	FLUID NAME
Clariant	Safewing MP IV 1957
Clariant	Safewing MP IV 2001
Kilfrost	Kilfrost ABC-S
Ely Chemical	Max-Flight
Octagon Process	Max-Flight
SPCA	SPCA AD-480
Union Carbide	UCAR®AAF ULTRA+

[†] Qualified solely with respect to anti-icing performance and aerodynamic acceptance by the Anti-icing Materials International Laboratory, Université du Québec à Chicoutimi.
For other material specification requirements refer to SAE AMS 1424 and 1428.

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TABLE 6

SAE TYPE I DEICING FLUID APPLICATION PROCEDURES

Guidelines for the application of SAE Type I fluid mixtures at minimum concentrations for the prevailing outside air temperature (OAT)

Outside Air Temperature OAT	One-step Procedure	Two-step Procedure	
	Deicing/anti-icing	First step: Deicing	Second step: Anti-icing [1]
-3°C (27°F) and above	FP of heated fluid [2] mixture shall be at least 10°C (18°F) below OAT	Water heated to 60°C (140°F) minimum at the nozzle or a heated mix of fluid and water	FP of fluid mixture shall be at least 10°C (18°F) below OAT
Below -3°C (27°F)		FP of heated fluid mixture shall not be more than 3°C (5°F) above OAT	

NOTE: For heated fluids, a fluid temperature not less than 60°C (140°F) at the nozzle is desirable. Upper temperature limit shall not exceed fluid and aircraft manufacturers' recommendations.

CAUTION: Wing skin temperatures may differ and in some cases may be lower than OAT. A stronger mix (more Glycol) can be used under the latter conditions.

[1] To be applied before first-step fluid freezes, typically within 3 minutes.

[2] Clean aircraft may be anti-iced with unheated fluid.

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TABLE 7

SAE TYPE II and TYPE IV ANTI-ICING FLUID APPLICATION PROCEDURES

Guidelines for the application of SAE Type II and IV fluid mixtures (minimum concentrations in % by volume) as a function of outside air temperature (OAT)

Outside Air Temperature OAT	One-step Procedure	Two-step Procedure	
	Deicing/anti-icing	First step: Deicing	Second step: Anti-icing [1]
-3°C (27°F) and above	50/50 Heated [2] Type II/IV	Heated water or a heated mix of Type I, II or IV with water	50/50 Type II/IV
Below -3°C (27°F) to -14°C (7°F)	75/25 Heated [2] Type II/IV	Heated suitable mix of Type I, Type II/IV and water with FP not more than 3°C (5°F) above actual OAT	75/25 Type II/IV
Below -14°C (7°F) to -25°C (-13°F)	100/0 Heated [2] Type II/IV	Heated suitable mix of Type I, Type II/IV and water with FP not more than 3°C (5°F) above actual OAT	100/0 Type II/IV
Below -25°C (-13°F)	SAE Type II/IV fluid may be used below -25°C (-13°F) provided that the freezing point of the fluid is at least a 7°C (13°F) below OAT and that aerodynamic acceptance criteria are met. Consider the use of SAE Type I when Type II/IV fluid cannot be used (see Table 6).		

NOTE: For heated fluids, a fluid temperature not less than 60°C (140°F) at the nozzle is desirable. Upper temperature limit shall not exceed fluid and aircraft manufacturers' recommendations.

CAUTION: Wing skin temperatures may differ and in some cases may be lower than OAT. A stronger mix (more Glycol) can be used under the latter conditions.

An insufficient amount of anti-icing fluid may cause a substantial loss of holdover time. This is particularly true when using a Type I fluid mixture for the first step in a two-step procedure.

[1] To be applied before first-step fluid freezes, typically within 3 minutes.

[2] Clean aircraft may be anti-iced with unheated fluid.

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TABLE 8

SNOW VISIBILITY VS SNOWFALL INTENSITY CHART

Lighting	Temperature Range		Visibility in Statute Miles		
	°C	°F	Heavy*	Moderate*	Light*
Daylight	Above -1	Above 30	<1	1 - 2	>2
	-1 to -7	30 to 19	<1/2	1/2 - 1 1/4	>1 1/4
	Below -7	Below 19	<3/8	3/8 - 5/8	>5/8
Darkness	Above -1	Above 30	<2	2 - 4	>4
	-1 to -7	30 to 19	<1	1 - 2 1/2	>2 1/2
	Below -7	Below 19	<3/4	3/4 - 1 1/4	>1 1/4

* Light snow intensity is defined as less then 1mm/hr equivalent liquid water, moderate intensity as 1 mm/hr to 2.5mm/hr equivalent liquid water, and heavy as greater than 2.5mm/hr equivalent liquid water.

TRANSPORT CANADA, AUGUST 1999

APPENDIX I

TEST PROCEDURE FOR THE DETERMINATION OF FILM THICKNESS PROFILES FOR DEICING AND ANTI-ICING FLUIDS ON FLAT PLATES

EXPERIMENTAL PROGRAM
TO ESTABLISH FILM THICKNESS PROFILES FOR DE-ICING AND ANTI-ICING FLUIDS ON FLAT PLATES
CLIMATIC ENGINEERING FACILITY

Feb 8, 1999
Version 1.0

1. OBJECTIVE

Establish film thickness profiles for de-icing and anti-icing fluids on flat plates.

2. TEST REQUIREMENTS

APS will coordinate a series of trials (see Attachment I-I) at the NRC Climatic Engineering Facility in Ottawa. Tests will be planned and coordinated specifically to establish fluid thickness profiles, in which test weather conditions will include an air temperature of -15°C to -0°C, varying winds, and no precipitation.

Thickness of the fluid film on the plates will be measured and recorded at a pre-defined location along a selected cross-section. Fluid thickness measures will be taken on a continuous basis and the clock time for each measure will be recorded. Other data recorded will include ambient meteorological conditions. Tests should be conducted on C/FIMS mounted plates if available, and the logging of this data must be started prior to fluid application.

3. EQUIPMENT

Equipment to be employed is described in Attachment I-II.

4. PERSONNEL

One or two persons are required for each occasion (see Attachment I-III).

5. PROCEDURE

The test procedure is included in Attachment I-IV.

6. DATA FORM

The data form for measuring thickness is included as Attachment I-VI.

ATTACHMENT I-I

Fluid Thickness Test Matrix

Run #	Fluid Manufac.	Fluid Dilution	Brand Name	Outside Air Temperature	Comments
1	Clariant	Neat (NS)	Safewing Four	-3	*Non-sheared*
2	Clariant	Neat (NS)	Safewing Four	-3	*Non-sheared*
3	Clariant	Neat	Safewing Four	-3	*Sheared*
4	Clariant	Neat	Safewing Four	-3	*Sheared*
5	Clariant	75/25	Safewing Four	-3	*Sheared*
6	Clariant	75/25	Safewing Four	-3	*Sheared*
7	Clariant	50/50	Safewing Four	-3	*Sheared*
8	Clariant	50/50	Safewing Four	-3	*Sheared*
9	Clariant	Neat (NS)	Safewing MP IV 1957	-3	*Non-sheared*
10	Clariant	Neat (NS)	Safewing MP IV 1957	-3	*Non-sheared*
11	Clariant	Neat	Safewing MP IV 1957	-3	*Sheared*
12	Clariant	Neat	Safewing MP IV 1957	-3	*Sheared*
13	Clariant	75/25	Safewing MP IV 1957	-3	*Sheared*
14	Clariant	75/25	Safewing MP IV 1957	-3	*Sheared*
15	Clariant	50/50	Safewing MP IV 1957	-3	*Sheared*
16	Clariant	50/50	Safewing MP IV 1957	-3	*Sheared*
17	Kilfrost	Neat (NS)	Kilfrost ABC 3+	-3	*Non-sheared*
18	Kilfrost	Neat (NS)	Kilfrost ABC 3+	-3	*Non-sheared*
19	Kilfrost	Neat	Kilfrost ABC 3+	-3	*Sheared*
20	Kilfrost	Neat	Kilfrost ABC 3+	-3	*Sheared*
21	Kilfrost	75/25	Kilfrost ABC 3+	-3	*Sheared*
22	Kilfrost	75/25	Kilfrost ABC 3+	-3	*Sheared*
23	Kilfrost	50/50	Kilfrost ABC 3+	-3	*Sheared*
24	Kilfrost	50/50	Kilfrost ABC 3+	-3	*Sheared*
25	Kilfrost	Neat (NS)	Kilfrost ABC S	-3	*Non-sheared*
26	Kilfrost	Neat (NS)	Kilfrost ABC S	-3	*Non-sheared*
27	Kilfrost	Neat	Kilfrost ABC S	-3	*Sheared*
28	Kilfrost	Neat	Kilfrost ABC S	-3	*Sheared*
29	Kilfrost	75/25	Kilfrost ABC S	-3	*Sheared*
30	Kilfrost	75/25	Kilfrost ABC S	-3	*Sheared*
31	Kilfrost	50/50	Kilfrost ABC S	-3	*Sheared*
32	Kilfrost	50/50	Kilfrost ABC S	-3	*Sheared*
33	Octagon	Neat	Maxflight	-3	*Sheared*
34	Octagon	Neat	Maxflight	-3	*Sheared*
35	Octagon	75/25	Maxflight	-3	*Sheared*
36	Octagon	75/25	Maxflight	-3	*Sheared*
37	Octagon	50/50	Maxflight	-3	*Sheared*
38	Octagon	50/50	Maxflight	-3	*Sheared*
39	SPCA	Neat	AD 480	-3	*Sheared*
40	SPCA	Neat	AD 481	-3	*Sheared*
41	SPCA	75/25	AD 482	-3	*Sheared*
42	SPCA	75/25	AD 483	-3	*Sheared*
43	Union Carbide	Neat	Ultra +	-3	*Sheared*

Run #	Fluid Manufac.	Fluid Dilution	Brand Name	Outside Air Temperature	Comments
44	Union Carbide	Neat	Ultra +	-3	*Sheared*
45	Union Carbide	75/25	Ultra +	-3	*Sheared*
46	Union Carbide	75/25	Ultra +	-3	*Sheared*
47	Union Carbide	50/50	Ultra +	-3	*Sheared*
48	Union Carbide	50/50	Ultra +	-3	*Sheared*
49	Inland	Recycled Ethylene	3R-Duragly-E	-3	
50	Inland	Recycled Ethylene	3R-Duragly-E	-3	
51	Inland	Recycled Ethylene	3R-Duragly-E	-3	
52	Inland	Recycled Ethylene	3R-Duragly-E	-3	
53	APS Aviation	Fluid X	I	-3	
54	APS Aviation	Fluid X	I	-3	
55	APS Aviation	Fluid X	I	-3	
56	APS Aviation	Fluid X	I	-3	

Notes:

- **NS: Non-Sheared**
- **If the results from the two tests for one fluid vary by more than 10% repeat the two tests and disreguard the highest and lowest values**
- **The quantity of fluid that will be poured for each test is 1.5 L**

ATTACHMENT I-II

FLUID THICKNESS PROFILE TESTS
TEST EQUIPMENT CHECKLIST - PLATES @ NRC

TASK	***Montreal***	
	Resp.	**Status**
Test Equipment		
Tape Recorder with Mic.(voice) - Optional		
Supply of tapes for recorder		
Supply of AA cells		
Thickness Gauges - 8 hand held, 6 mounted on poles		
General Data Forms		
Compass		
Clipboard		
Space pens and pencils		
Lighting		
C/FIMS Sensors		
Hands-free flashlight		
Cloth wipers for gauges		
Cotton gloves (mechanics type)		
Stop watch		
Protective clothing		
Still camera		
Fluids		
Industrial Fan (from NRC)		
Hand Held Anemometer (from NRC)		
Garden Sprayer Equipment		

ATTACHMENT I-III

FLUID THICKNESS PROFILE TESTS

RESPONSIBILITIES/DUTIES OF TEST PERSONNEL

Refer to Attachment V for measurement position on plates. Refer to the test procedure Attachment IV for more detail.

Observer

X Ensure clocks are synchronised.
X Located by test stand.
X Before each test run, record your name, C/FIMS #, date and time, the run number, fluid type.
X Indicate time of fluid application.
X Progressively measure fluid thickness at assigned measurement locations:
  - Use the MIL scale on the gauge
  - Record the gauge of the tooth that is wetted
  - When measuring fluid thickness, follow offset routine (see Attachment V) to avoid inaccuracies related to depressions in fluid surface caused by previous gauge placement.
  - Ensure the thickness gauge is perpendicular to the surface of the wing.
  - Record time in seconds during the initial measurement cycle when the rate of fluid thinning is fastest. Time to the nearest minute is acceptable for subsequent recording.
  - Proceed as quickly as possible without sacrificing accuracy.

X For each measurement, record plate identification, the measurement location, the time, and the fluid thickness gauge reading.
Example: Plate u, line six inch, time 024238, gauge 55 mil.
Always say the words preceding the data (plate, line, time, gauge) to voice activate the tape recorder if this is being used. Speak clearly.
X Alternatively, measurements could be recorded directly on the data form.
X Ensure all recorded voice tapes are properly tagged (date, observer, run #, etc.) and submitted to the project manager.
X Review data forms at test completion for completeness and accuracy.
X Ensure functioning of voice recorders, in particular the voice activation function.
X Ensure proper documentation of voice and video tapes, and of fluid samples.
X Call end of test based on fluid thinning reaching state of stability.

If the data is being recorded directly onto the data form, then two observers would be required for the first 5 to 10 minutes.

ATTACHMENT I-IV
FLUID THICKNESS PROFILE TESTS

TEST PROCEDURE

1. Pre-Test Set-Up

Synchronize time on stopwatches.

Locate positions where fluid thickness readings will be taken.

Use up to six plates with C/FIMS mounted, if available.

Turn on C/FIMS computer for the fluids being tested.

2. Test Procedure

Ensure test stand is into the wind.

Apply test fluid over the test panels as per standard flat plate test procedure. Some tests will require a one minute spray application. Type IV should be at chamber temperatures and Type I at room temperature.

Some tests will be conducted with a two-step Type I initial application.

Observers will measure and record fluid thickness at each assigned measurement location. Record the location and the time corresponding to each measurement.

For each tests (see Attachment I), record the thickness on the 6" line. For the six inch line, ensure accuracy by measuring two times.

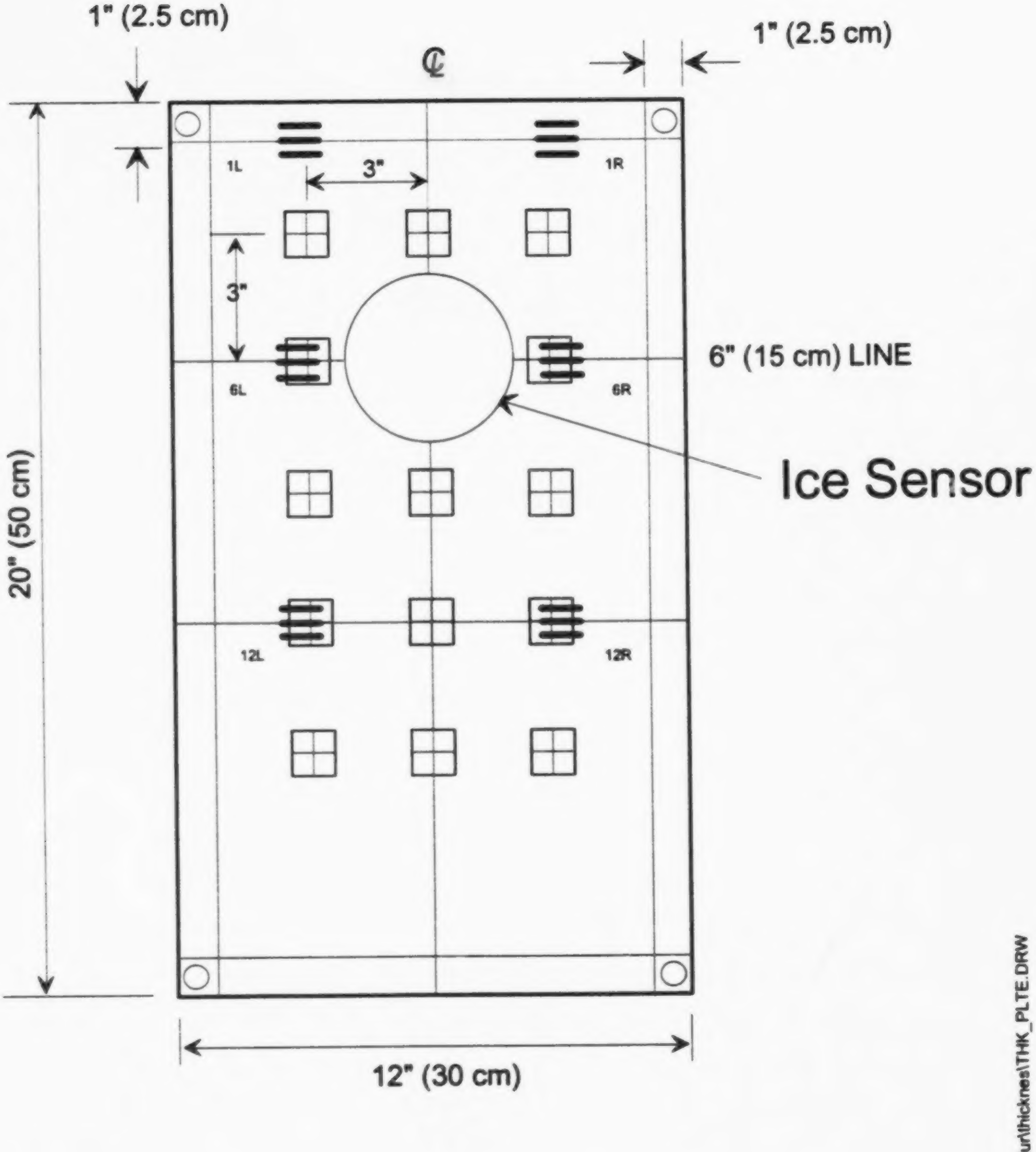
3. End of Test

The test will be terminated when fluid thickness stabilises.

Ensure all voice tapes (if this is used) are properly identified and then transcribed onto paper.

ATTACHMENT I-V

THICKNESS MEASUREMENT LOCATIONS ON STANDARD PLATE


1" (2.5 cm)
1" (2.5 cm)
℄
1L
1R
3"
3"
6" (15 cm) LINE
6L
6R
Ice Sensor
20" (50 cm)
12L
12R
12" (30 cm)

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ATTACHMENT I-VI

FLUID THICKNESS TEST

DATE: ____________
TEST #: ______ to ______
STAND: ____________

TEMPERATURE °C (beg.): ____________
WIND SPEED, kph (beg.): ____________
LOCATION: CEF (NRC)

PERFORMED BY: ____________
WRITTEN BY: ____________

THICKNESS (mil)											
Plate: **U** Run #: Fluid: Application Time:		Plate: **V** Run #: Fluid: Application Time:		Plate: **W** Run #: Fluid: Application Time:		Plate: **X** Run #: Fluid: Application Time:		Plate: **Y** Run #: Fluid: Application Time:		Plate: **Z** Run #: Fluid: Application Time:	
TIME	**6" LINE**	**TIME**	**6" LINE**	**TIME**	**6" LINE**	**TIME**	**6" LINE**	**TIME**	**6" LINE**	**TIME**	**6" LINE**

APPENDIX J

TEST PLAN FOR RECYCLED FLUID HOLDOVER TIME TESTS IN NATURAL SNOW

CM1514.001

EXPERIMENTAL PROGRAM
TEST PLAN FOR RECYCLED FLUID HOLDOVER TIME TESTS IN NATURAL SNOW

Winter 1998-99

APS AVIATION INC. APS

December 2, 1998
Version 1.0

EXPERIMENTAL PROGRAM
TEST PLAN FOR RECYCLED FLUID HOLDOVER TIME TESTS IN NATURAL SNOW

Winter 1998-99

1. OBJECTIVE

The objective of this series of tests is to establish a sound base of data sufficient to establish valid holdover times for Inland's recycled fluid in natural snow conditions and to determine and demonstrate compatibility with commercial brands of Type I and Type IV fluid.

2. PLAN

Attachment J-I provides the number of series of tests to be conducted at the Dorval test site adjacent to Atmospheric Environment Services. Attachments J-II and J-III provide the list of fluids to be tested simultaneously for each series of tests. Tests shall be conducted during natural precipitation conditions.

3. EQUIPMENT

Test equipment required for the flat plate tests was determined from previous winters in association with the Society of Automotive Engineers (SAE) working group. This equipment is listed in Attachment B-II of Appendix B.

4. PERSONNEL

The personnel requirements for the conduct of these tests are similar to those in Appendix B.

5. PROCEDURE

The modified test procedure is included in Attachment B-II of Appendix B. This procedure was developed more than five years ago and was modified over the years to incorporate discussions at the SAE working group meetings.

Several changes have been made to the procedure in Attachment B-II:

- A refined procedure for the collection of precipitation rates has been developed and is shown in Attachment B-VII of Appendix B; and

- At the time of plate failure (5th crosshair failure), the refractive index of the failed fluid at the point of failure will be recorded using a hand-held refractometer.

Each series of recycled fluid holdover time and fluid compatibility tests should be conducted simultaneously. For example, in Attachment J-II of this document, each set of compatibility tests (four plates for Type IV and three plates for Type I) should be run at the same time on the same test stand.

6. DATA FORMS

The data forms required for the conduct of recycled fluid testing in natural snow, the End Condition Data Form (Table B-1) and the Meteo/Plate Pan Data Form (Table B-2), appear in Appendix B.

ATTACHMENT J-I

TEST PLAN FOR RECYCLED FLUID HOT AND FLUID COMPATIBILITY TESTS

NATURAL SNOW CONDITIONS

WINTER 1998-99

OAT (°C)	**Holdover Time**	**Fluid Compatibility**
above 0	Run tests in Attachment J-III two times	Run tests in Attachment J-II (A, B and C) one time
0 to -10	Run tests in Attachment J-III five times	Run tests in Attachment J-II (A, B and C) three times
below -10	Run tests in Attachment J-III two times	Run tests in Attachment J-II (A, B and C) one time

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At: Plan 1

ATTACHMENT J-II

RECYCLED FLUID COMPATIBILITY TESTS

NATURAL SNOW CONDITIONS

WINTER 1998-99

Type IV Fluids (Dependent on results, also consider using diluted or other fluid types)

A) UCAR Ultra+ Type IV (Simultaneous)

Ultra+ IV	Ultra+ IV over Type 0 (Ethylene)	Ultra+ IV over Type 0 (Propylene)	Ultra+ IV over XL54

B) Octagon Maxflight (Simultaneous)

Octagon IV	Octagon IV over Type 0 (Ethylene)	Octagon IV over Type 0 (Propylene)	Octagon IV over Octagon I

Type I Fluids

C) UCAR XL54 Type I and Octagon Type I (Simultaneous)

XL54	XL54 over Type 0 (Ethylene)	XL54 over Type 0 (Propylene)
Octagon I	Octagon I over Type 0 (Ethylene)	Octagon I over Type 0 (Propylene)

ATTACHMENT J-III

RECYCLED FLUID HOLDOVER TIME TESTS

NATURAL SNOW CONDITIONS

WINTER 1998-99

Octagon I	XL54	Type 0 (Ethylene)	Type 0 (Propylene)

NB: These are simultaneous tests.

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APPENDIX K

PLAN FOR FROST DEPOSITION MEASUREMENT TESTS ON FLAT PLATES

CM1514.001

EXPERIMENTAL PROGRAM PLAN FOR FROST TESTS ON FLAT PLATES

Winter 1998-99

APS AVIATION INC. APS

December 2, 1998
Version 1.0

EXPERIMENTAL PROGRAM
PLAN FOR FROST TESTS ON FLAT PLATES
December 2, 1998, Version 1.0
Winter 1998-99

- The ideal conditions for the development of frost are:
  i) Less than two knots of wind;
  ii) Clear sky preferred; and
  iii) Dew point and ambient temperatures comparable.

- Frost tests will be conducted overnight.

- Surfaces to be tested include standard aluminium flat plates, 0.020" aluminium honeycomb core plates and composite plates.

- Prior to being placed on the test stand, test surfaces should be weighed to the nearest gram. Weights should be recorded on a meteo/plate pan data form (Table K-2).

- Once test surface weights have been recorded, the test surfaces should be placed on the test stand. Ensure that the test stand is properly inclined at 10°. Ensure that test start times are recorded.

- Reweigh the test surfaces at 2-hour intervals to determine frost deposition.

- Two additional standard plates should be coated with Type I XL54 and Ultra+ Type IV. Following the pouring of fluids, record the start times.

- If/When frost builds on the plate, record the failure time when five crosshairs on the plate have failed. Record failure times on an End Condition Data Form (Table K-1).

- For Type IV tests, a measure of Brix (at the top and bottom layer of the fluid) and fluid thickness is required at one-hour intervals.

- Test surfaces used to determine frost deposition should be reweighed following plate failure.

TABLE K-1

END CONDITION DATA FORM

VERSION 5.0 Winter 97/98

REMEMBER TO SYNCHRONIZE TIME WITH AES - USE REAL TIME

LOCATION: **DATE:** **RUN # :** **STAND # :**

RVSI Series # : ____________________

CIRCLE SENSOR PLATE: u v w x y z

SENSOR NAME: ___ ___ ___ ___ ___ ___

DIRECTION OF STAND:______ °

OTHER COMMENTS (Fluid Batch, etc):

____

____

____

____

____

____

____

____

	PRINT	SIGN
FAILURES CALLED BY :		
HAND WRITTTEN BY :		
TEST SITE LEADER :		

***TIME (After Fluid Application) TO FAILURE FOR INDIVIDUAL CROSSHAIRS (hr:min)**

Time of Fluid Application: ______ hr:min (U & X) ______ hr:min (V & Y) ______ hr:min (W & Z)

	Plate U			Plate V			Plate W		
FLUID NAME									
B1 B2 B3									
C1 C2 C3									
D1 D2 D3									
E1 E2 E3									
F1 F2 F3									
TIME TO FIRST PLATE FAILURE WITHIN WORK AREA									
CALCULATED FAILURE TIME (MINUTES)									
BRIX AT FAILURE									

	Plate X			Plate Y			Plate Z		
FLUID NAME									
B1 B2 B3									
C1 C2 C3									
D1 D2 D3									
E1 E2 E3									
F1 F2 F3									
TIME TO FIRST PLATE FAILURE WITHIN WORK AREA									
CALCULATED FAILURE TIME (MINUTES)									
BRIX AT FAILURE									

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At: Data Form

METEO/PLATE PAN DATA FORM

VERSION 6.0 Winter 98/99

REMEMBER TO SYNCHRONIZE TIME WITH AES - USE REAL TIME

RUN # : **STAND # :**

LOCATION: **DATE:**

HAND HELD VIDEO CASSETTE #:

PLATE PAN WEIGHT MEASUREMENTS *

PAN #	t TIME BEFORE (hh:mm:ss)	BUFFER TIME (Seconds)	t TIME AFTER (hh:mm:ss)	BUFFER TIME (Seconds)	w WEIGHT BEFORE (grams)	w WEIGHT AFTER (grams)	COMPUTE RATE (Δ w*4.7/Δt) (g/dm^2/h)

*measurements every 15 min. and at failure time of each test panel.

METEO OBSERVATIONS **

TIME (hr:min)	TYPE (Fig. 4) ZR, ZL,S, SG IP, IC, BS, SP	CLASSIF. (See Fig. 3)	If SNOW, WET or DRY

**observations at beginning, end, and every 10 min. intervals. Additional observations when there are significant changes.

TEMPERATURE AT START OF TEST ________ °C

WIND SPEED AT START OF TEST ________ kph

WIND DIRECTION AT START OF TEST ________ °

COMMENTS : ______________________________

____

____

____

	PRINT	SIGN
WRITTEN & PERFORMED BY :	________	________
VIDEO BY :	________	________
TEST SITE LEADER :	________	________

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APPENDIX L

PLAN FOR FROST DEPOSITION MEASUREMENT TESTS ON FLAT PLATES – NORTHERN AIRPORTS

CM1514.001

EXPERIMENTAL PROGRAM
PLAN FOR FROST TESTS ON FLAT PLATES - NORTHERN AIRPORTS

Winter 1998-99

APS AVIATION INC.

January 21, 1999
Version 1.0

EXPERIMENTAL PROGRAM
PLAN FOR FROST TESTS ON FLAT PLATES - NORTHERN AIRPORTS

January 21, 1999
Version 1.0
Winter 1998-99

- The ideal conditions for the development of frost are:
  - i) Less than two knots of wind;
  - ii) Clear sky preferred; and
  - iii) Dew point and ambient temperatures comparable.
- Frost tests will be conducted overnight.
- Surfaces to be tested include standard 1/8" aluminium flat plate (Plate A), 1/16" aluminium painted plate [white] (Plate B), honeycomb carbon fibre composite (Plate C), and Kevlar/Aramid honeycomb composite (Plate D).
- Record test surface weights and time prior to placing on a 10° slope (approximately 3.5"high). Place surface such that wind is moving up the plate
- Reweigh the test surface at 1-hour intervals to determine frost deposition.
- Ensure no loss of frost during the reweighing process (i.e. frost does not melt when weighing and placing on table again-do not keep inside for too long).
- Repeat processes for each of the four plates.

METEO/PLATE PAN DATA FORM

REMEMBER TO SYNCHRONIZE TIME WITH AES - USE REAL TIME

VERSION 6.0 Winter 98/99

LOCATION: **DATE:** **RUN # :**

PLATE PAN WEIGHT MEASUREMENTS *

PLATE	t TIME BEFORE (hh:mm:ss)	w WEIGHT BEFORE (grams)	t TIME AFTER (hh:mm:ss)	w WEIGHT AFTER (grams)

TEMPERATURE AT START OF TEST________ °C

TEMPERATURE AT END OF TEST________ °C

____

COMMENTS : ______________________________

____

____

____

	PRINT	SIGN
WRITTEN & PERFORMED BY :	________	________
	________	________
	________	________
	________	________
	________	________
	________	________
	________	________

---

*measurements every hour with 5 minute interval between each plate.

APPENDIX M

EXPERIMENTAL PROCEDURE FOR THE COLLECTION OF FOG RATES OF DEPOSITION IN NATURAL CONDITIONS

CM1514.001

EXPERIMENTAL PROCEDURE FOR THE COLLECTION OF FOG RATES OF DEPOSITION IN NATURAL CONDITIONS

Winter 1998-99

APS AVIATION INC.

December 24, 1998
Version 1.0

Experimental Procedure for the Collection of Fog Rates of Deposition in Natural Conditions

Winter 1998-99
Version 1.0

1. OBJECTIVE

The objective of this study is to determine the range of deposition rates that occur naturally in fog.

2. PLAN

Collect fog deposition rates on several occasions in periods of natural fog or freezing fog.

3. PROCEDURE

A precipitation collection pan will be used to measure fog deposition rates in natural conditions. Prior to the start of the test, a collection pan will be coated with Ultra+ Type IV fluid (see flat plate test procedure) and weighed. The pan weight (in grams) and the test start time (hh:mm:ss) will then be recorded on a meteo/plate pan data form. In order to simulate the taxi of an aircraft in fog conditions, the collection pan will be mounted on a stand positioned on the hood of a car. In preliminary trials, the mounted pan will be inclined forward at 20°. Prior to the start of the test, zero the car odometer. The vehicle with the mounted plate pan should then be accelerated to a speed not exceeding 30 km/h for a period of 10 minutes in order to collect precipitation. Following the test, the distance traveled during the test will be recorded along with the test end time in order to calculate the average velocity during the test. Finally, the precipitation pan will be re-weighed in order to evaluate the fog catch.

Pending the results of these preliminary trials, the pan inclination, vehicle speed, and test duration may be modified accordingly.

4. PERSONNEL

One research assistant is required for these tests.

5. DATA FORMS

A Meteo / Plate Pan data form (see Table M-1) is required for these tests.

6. EQUIPMENT

- Weigh scale
- Precipitation plate pan
- Test plate mount for vehicle (to be designed)
- Inclinometer
- Type IV Ultra+ fluid

TABLE M-1

METEO/PLATE PAN DATA FORM (FOG DEPOSITION TRIALS)

Winter 98/99

LOCATION: **DATE:** **RUN # :**

PLATE PAN WEIGHT MEASUREMENTS

PAN #	t TIME BEFORE (hr:min:ss)	t TIME AFTER (hr:min)	w WEIGHT BEFORE (grams)	w WEIGHT AFTER (grams)	COMPUTE RATE $(\Delta w * 4.7/\Delta t)$ $(g/dm^2/h)$

COLLECTION PERIOD INFORMATION

TIME BEFORE (hr:min:ss)	TIME AFTER (hr:min:ss)	TOTAL DISTANCE TRAVELED

TEMPERATURE AT START OF TEST ______________ °C

COMMENTS : ________________________________

____

____

____

	PRINT	SIGN
WRITTEN & PERFORMED BY :	____________	____________
VIDEO BY :	____________	____________

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APPENDIX N

PRELIMINARY TESTING OF ICE-PHOBIC MATERIAL

CM1514.001

TEST PLAN
PRELIMINARY TESTING OF ICE PHOBIC MATERIAL

Winter 1998-1999

APS AVIATION INC. APS

December 4, 1998
Version 1.0

TEST PLAN
PRELIMINARY TESTING OF ICE PHOBIC MATERIAL
Winter 1998-1999

1. INTRODUCTION

This set of trials will encompass a preliminary evaluation of deicing and anti-icing fluid behavior when applied to surfaces finished with Dampney's Endcor 6400 Fuoro II Coating System. Each of these standard flat plates are to be coated with one of three modifications to the Endcor 6400 Fuoro II System:

1) a softer, high hydrophobicity modification;
2) a medium hardness, medium hydrophobicity modification; and
3) a harder, lower hydrophobicity modification.

2. PURPOSE

To evaluate substrate finish performance related to deicing and anti-icing fluids use.

3. TESTS

I. Fluid Adhesion Tests: Film, Beads, Bare

Thickness measurements are to be taken at <1 minute, at 3 minutes, 5 minutes, 10 minutes, and at 20 minutes after fluid applications. All times including the time at which fluid is poured (t=0) are to be recorded in hr:min format

II. Exposure Tests A (No Fluids)

Each of the three Endcor-coated plates are to be exposed to natural outdoor conditions without fluid treatment. Inspection for coating defects is to be conducted at the end of the two week period. In natural precipitation events, plates should be observed/monitored. In rain, fluid acceptance by surface should be inspected and photographed. In freezing precipitation, observe and record differences in ice accumulation relative to other coated and uncoated plates.

III. Exposure Tests B (Type IV Fluids)

Each of the three Endcor-coated plates are to be exposed to natural outdoor conditions for a 1 week period after Type IV fluid is applied. Fluid applied is to remain on surfaces for one week. In natural precipitation events, apply fresh fluid and observe.

4. EQUIPMENT

- Test Stand
- Flat Plates
- Fluids
- WFT Gauge
- Data Forms: see Attachment N-I.

5. PERSONNEL

Most tests require 1 person.

6. PROCEDURES

I Fluid Acceptance/ Resistance Tests

1) Mount 3 coated flat plates (upper row of test stand)
2) Mount 3 uncoated flat plates (lower row of test stand – stagger if possible)
3) For Type I fluid:
    - Pour 1 liter Type I fluid on 1rst LHS upper row plate, and note time (t=0).
    - Record state of fluid remaining on plate within 15 seconds (film, beads, dry & bare).
    - If a film persists, record the WFT at < 1 minute, at 3,5,10, and 20 minutes. Continue video and still photos (3 - <1 minute, at 5 minutes, at 20 minutes).
    - Repeat on 1rst lower row plate if film obtained.
    - Repeat for 2nd and 3rd plates (top and bottom).
4) Repeat 3 using Type IV fluid
5) Repeat 3 using two step fluid application (Type IV over Type I)

II Exposure Tests A (No Fluids)

No procedures required save visual and tactile inspection of coated and uncoated plates for relative comparison of icing rates

III Exposure Tests B (Type IV Fluids)

No procedure required save visual and tactile inspection. In icing conditions, measure crosshair failure times on each plate.

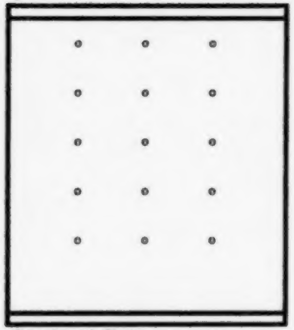
ATTACHMENT N-I

FLUID ACCEPTANCE/RESISTANCE TESTS

Date: ____________ Time: ________________

Run #: ____________ Fluid Name: ________________ Fluid Brand Type: ______________

t =

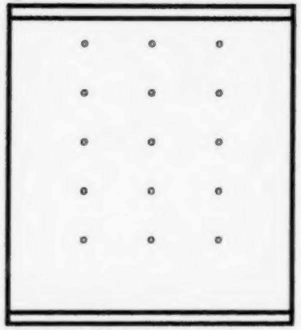


Coating 1 Plate

Film*/Beads/Dry

Time	Thickness (MILS)

t =

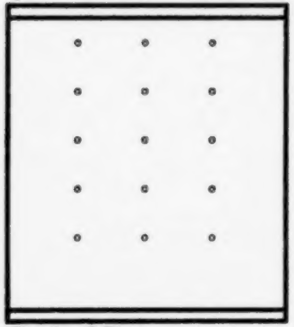


Coating 2 Plate

Film*/Beads/Dry

Time	Thickness (MILS)

t =

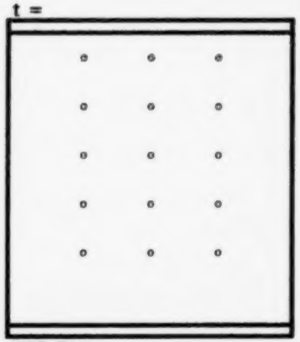


Coating 3 Plate

Film*/Beads/Dry

Time	Thickness (MILS)

t =



STD Plate

Film*/Beads/Dry

Time	Thickness (MILS)

Comments:

Note: Ensure observations made at t=0, 1st failure, 5th crosshair, whole plate
Make observations on C/FIMS

APPENDIX O

DROPLET SIZE TESTS

EXPERIMENTAL PROGRAM
DROPLET SIZE TESTS
December 8, 1999, Version 1.0
Winter 1998-99

Objective: To compare indoor versus outdoor droplet size in freezing rain and freezing drizzle conditions.

Plan: Conduct tests on four occasions and collect ten samples of droplet size. Tests can be conducted at home or at site when conducting other experiments.

Procedure: Validation experiments will be carried out using a manual dye-stain technique employed by the National Research Council Climatic Engineering Facility. This technique consists of dusting Whatman # 1 filter paper discs with a water-activated, very finely divided powder form of methylene blue dye. The prepared discs are manually positioned under precipitation for a fixed time in order to acquire a droplet size pattern. A calibration curve is than used to convert from the measured diameter of the droplets on the pattern to the experimental median volume diameter.

Personnel: One research assistant (BM)

- Measure precipitation rate if possible;
- Advise APS project coordinator after tests are conducted; and
- Ensure samples are sealed in plastic paper.

Form: Document the following on the back of the filter paper:

- Date:
- Time:
- Location (address):
- Precipitation condition (subjective):

Equipment: Refer to procedure.

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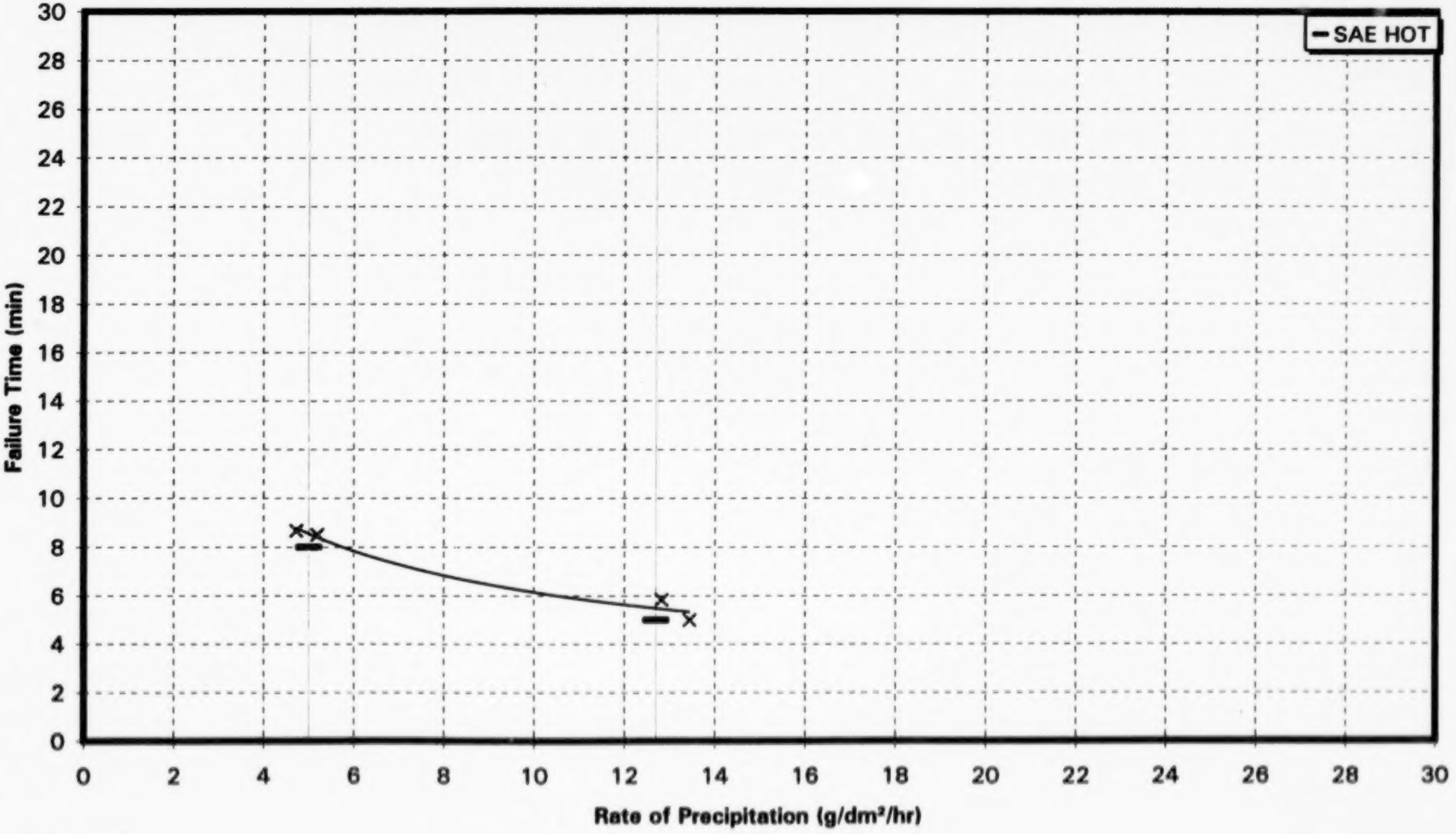
APPENDIX P

TYPE I FLUID TEST DATA

EFFECT OF RATE OF PRECIPITATION ON ENDURANCE TIME

HOME OIL SAFETEMP - TYPE I

SIMULATED FREEZING DRIZZLE AT -10°C

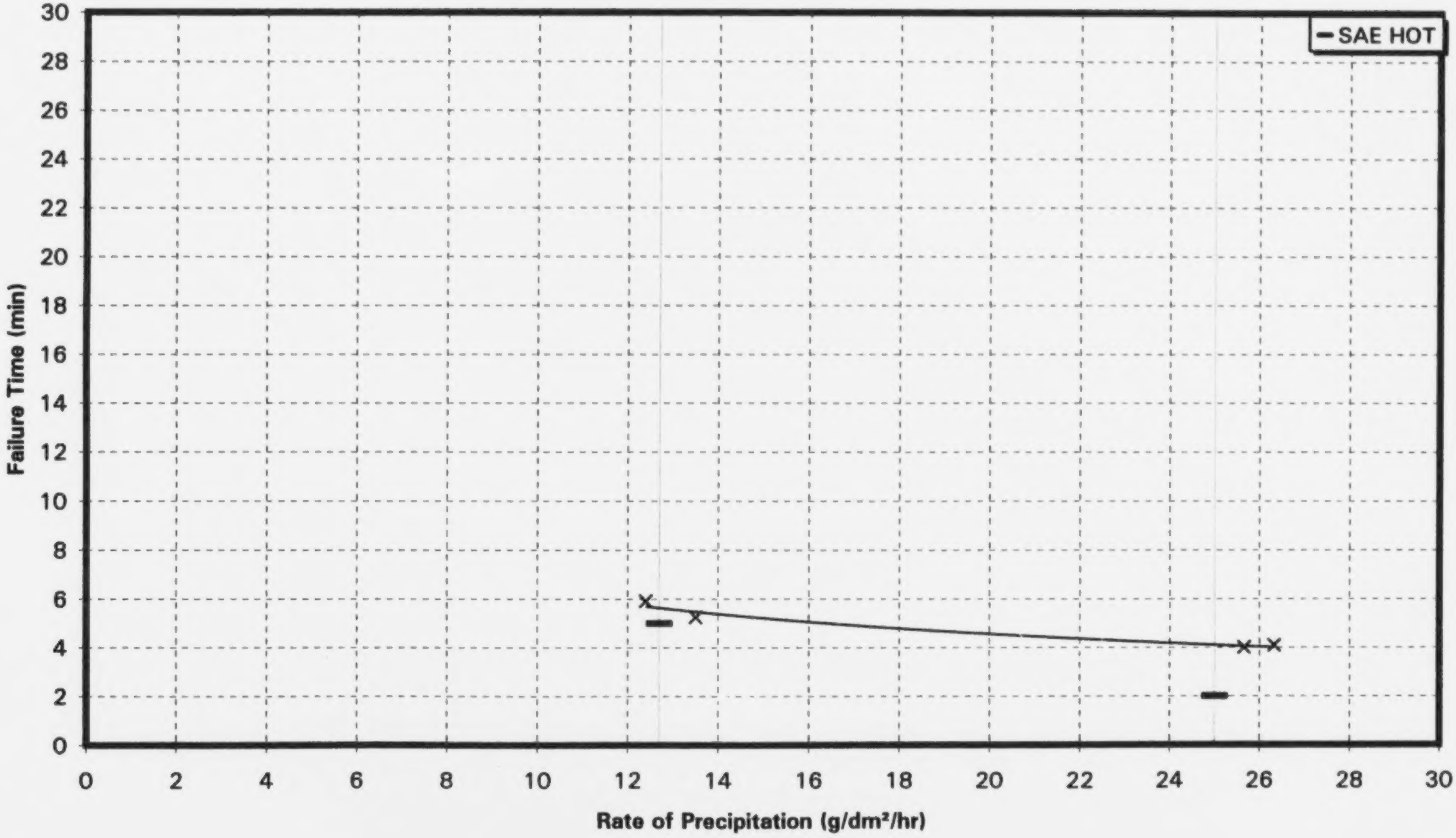


cm1514/analysis/type_1/charts/HOMEOIL
At: ZD

EFFECT OF RATE OF PRECIPITATION ON ENDURANCE TIME

HOME OIL SAFETEMP - TYPE I

SIMULATED LIGHT FREEZING RAIN AT -10°C

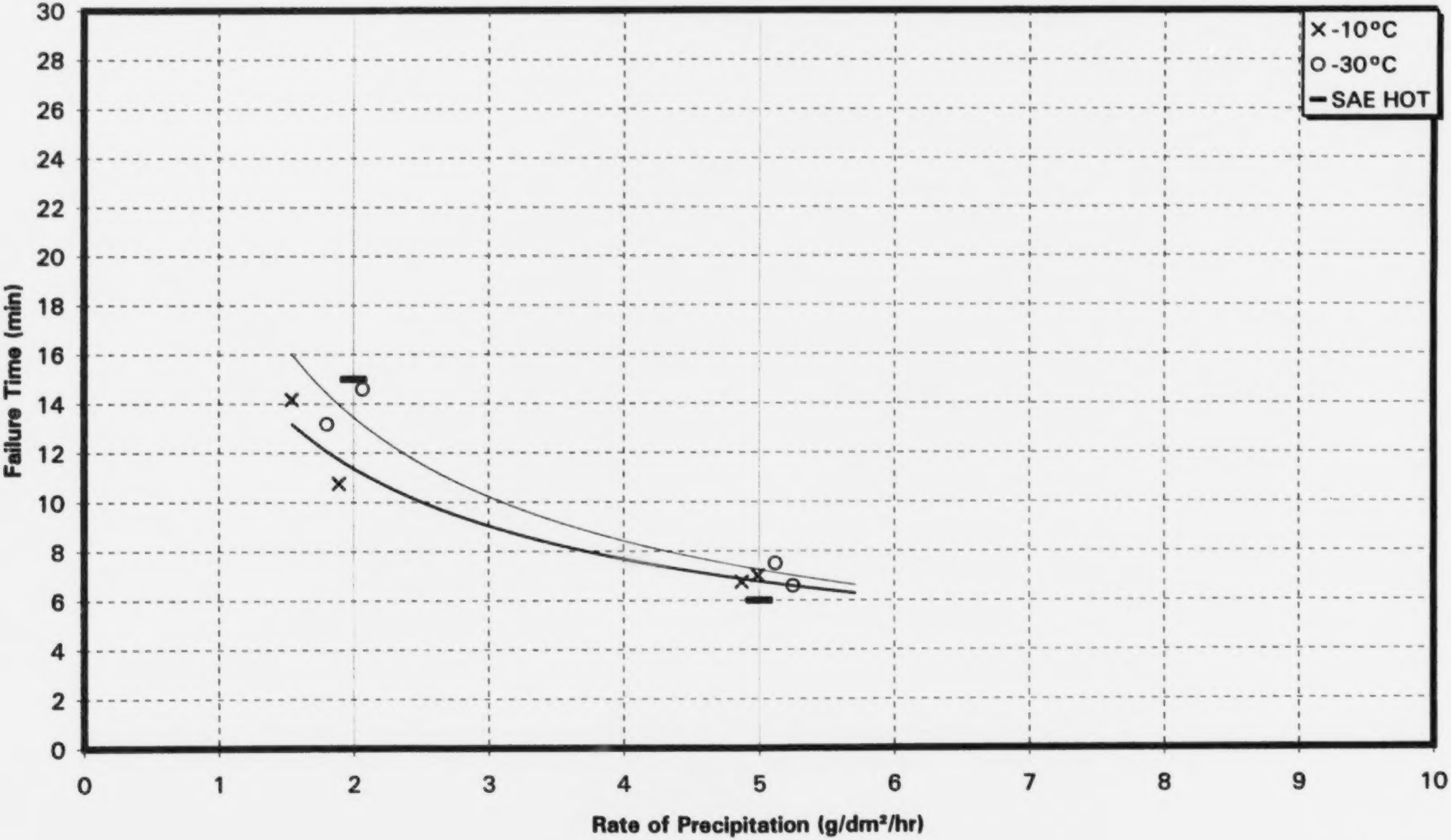


cm1514/analysis/type_1/charts/HOMEOIL
At: ZR

EFFECT OF TEMPERATURE AND RATE OF PRECIPITATION ON ENDURANCE TIME

HOME OIL SAFETEMP - TYPE I

SIMULATED FREEZING FOG

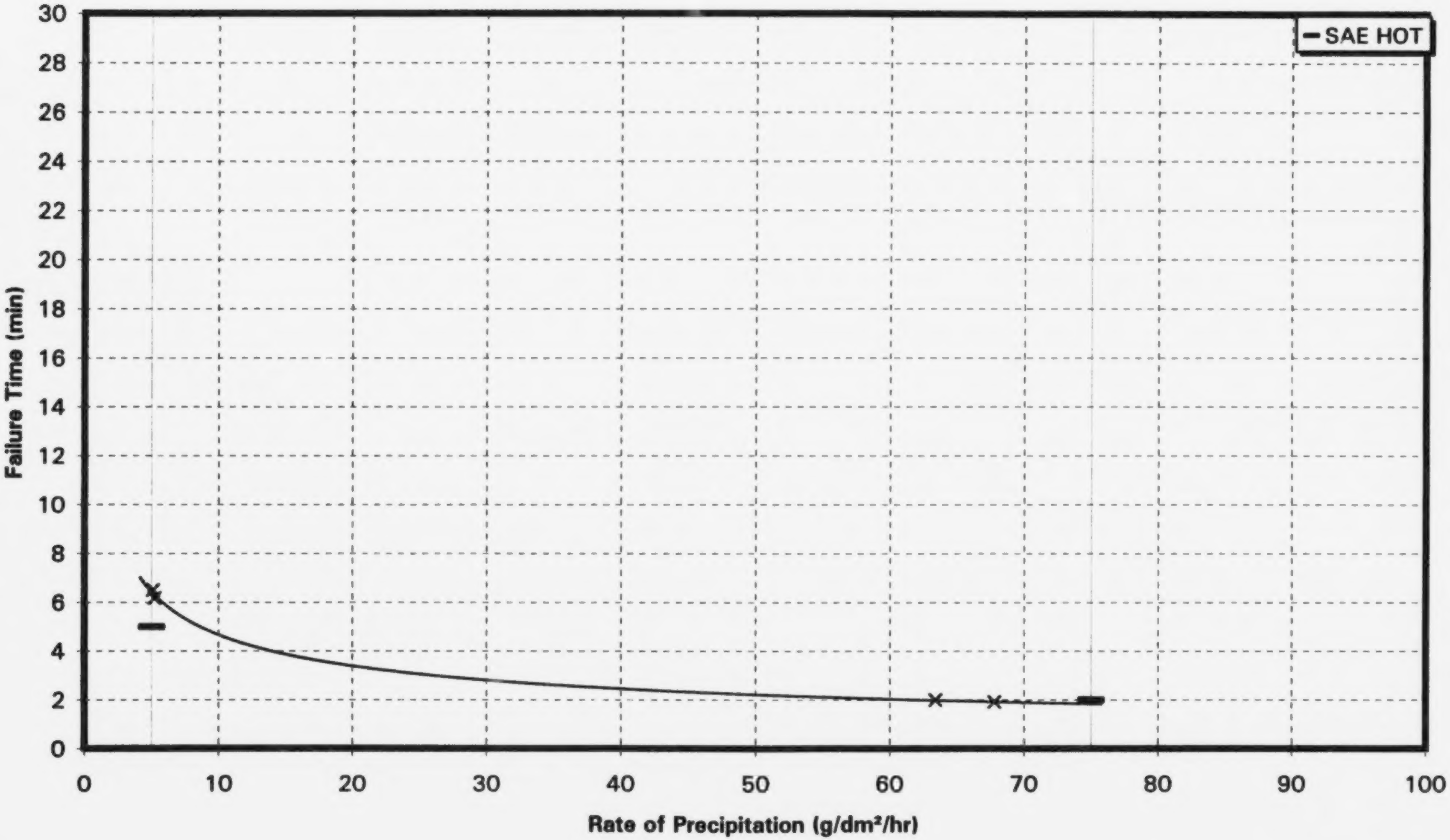


cm1514/analysis/type_1/charts/HOMEOIL
At: ZF

EFFECT OF RATE OF PRECIPITATION ON ENDURANCE TIME

HOME OIL SAFETEMP - TYPE I

RAIN ON COLD-SOAK SURFACE

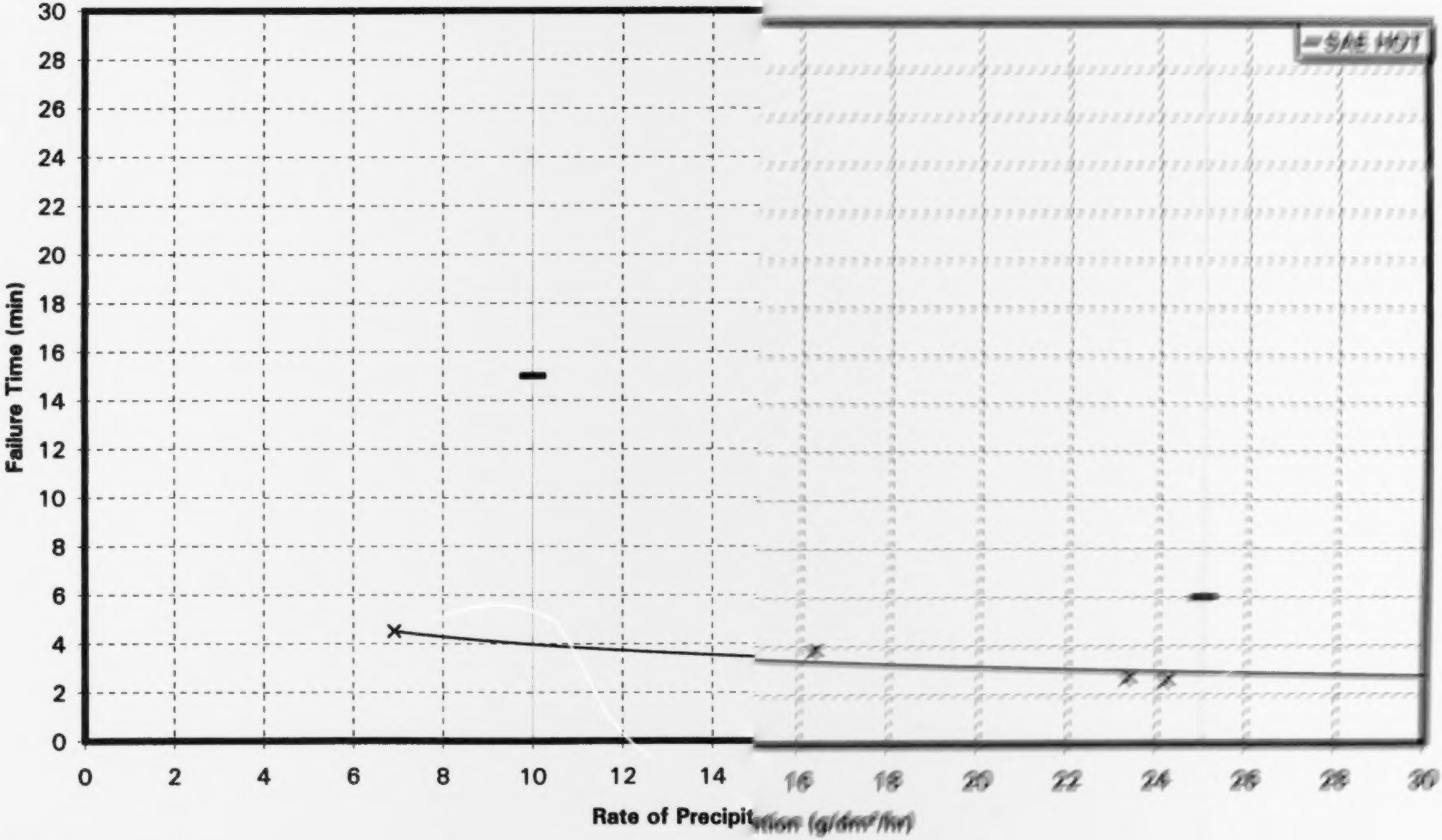


cm1514/analysis/type_1/charts/HOMEOIL
At: CS

EFFECT OF RATE OF PRECIPITATION ON ENDURANCE TIME

HOME OIL SAFETEMP - TYPE I

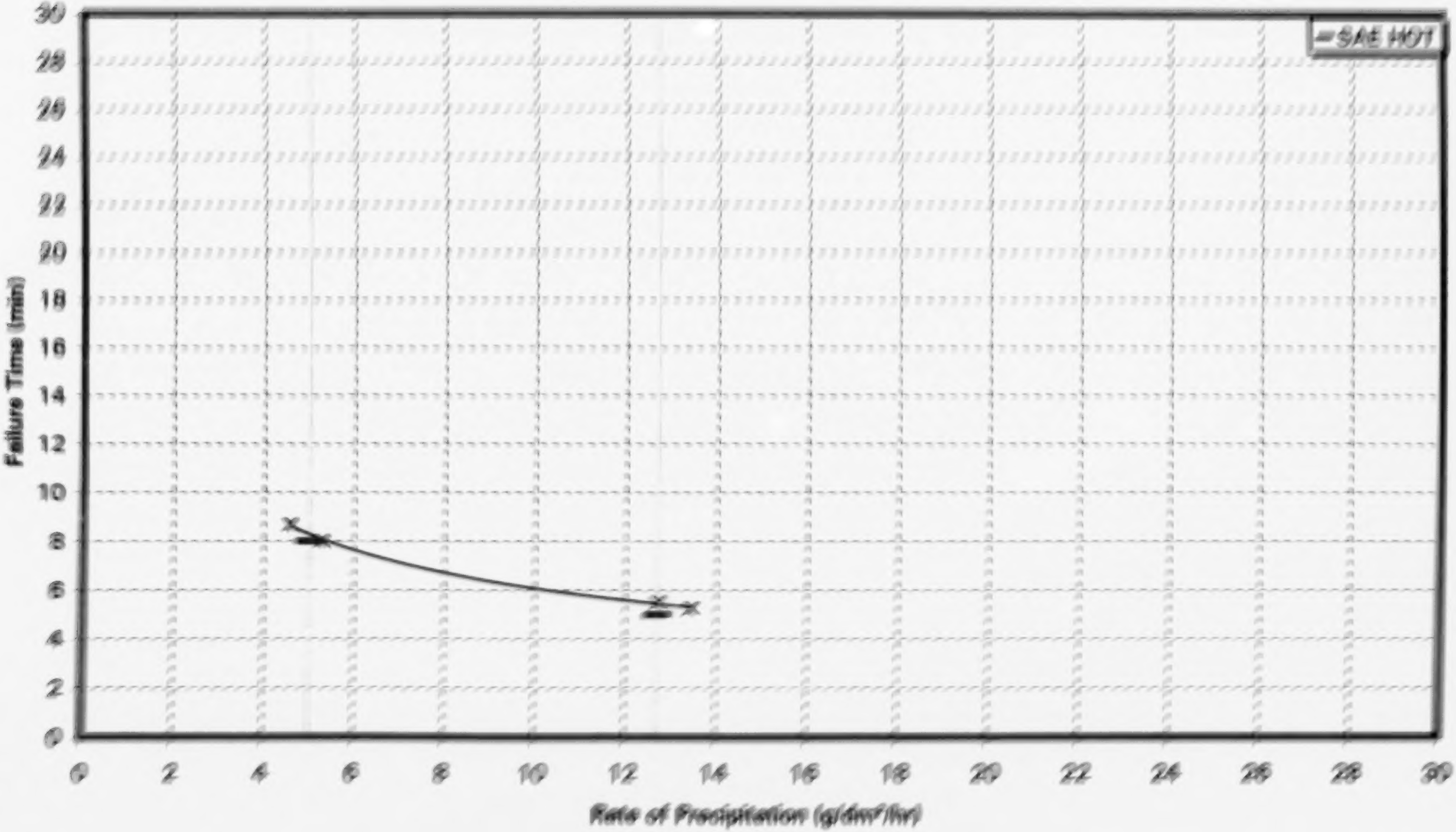
SIMULATED SNOW AT -10°C



EFFECT OF RATE OF PRECIPITATION ON ENDURANCE TIME

INLAND DURAGLY-P - TYPE I

SIMULATED FREEZING DRIZZLE AT -10°C

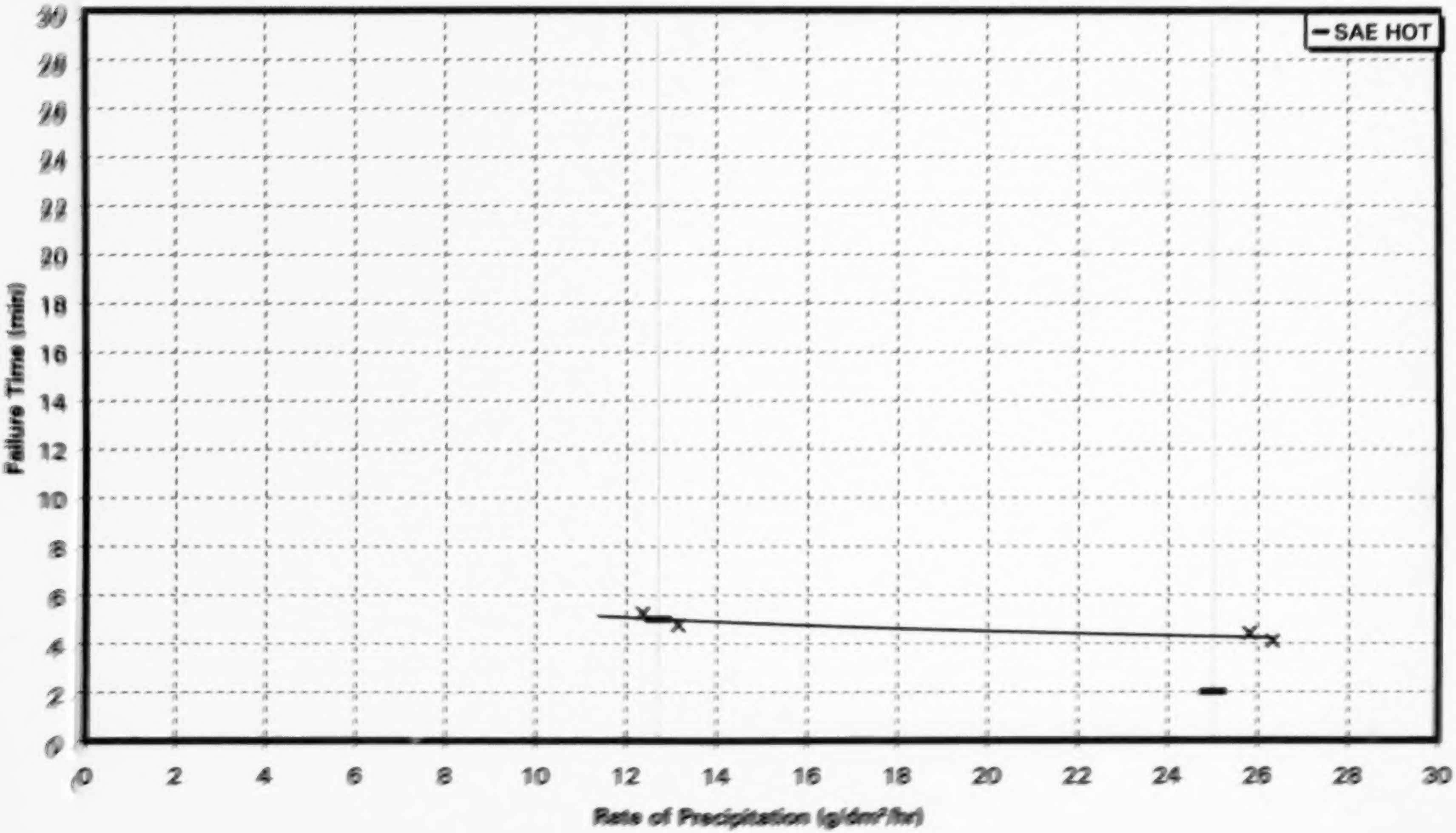


cm1614/analysis/type_1/charts/INLAND.F
At 20

EFFECT OF RATE OF PRECIPITATION ON ENDURANCE TIME

INLAND DURAGLY-P - TYPE I

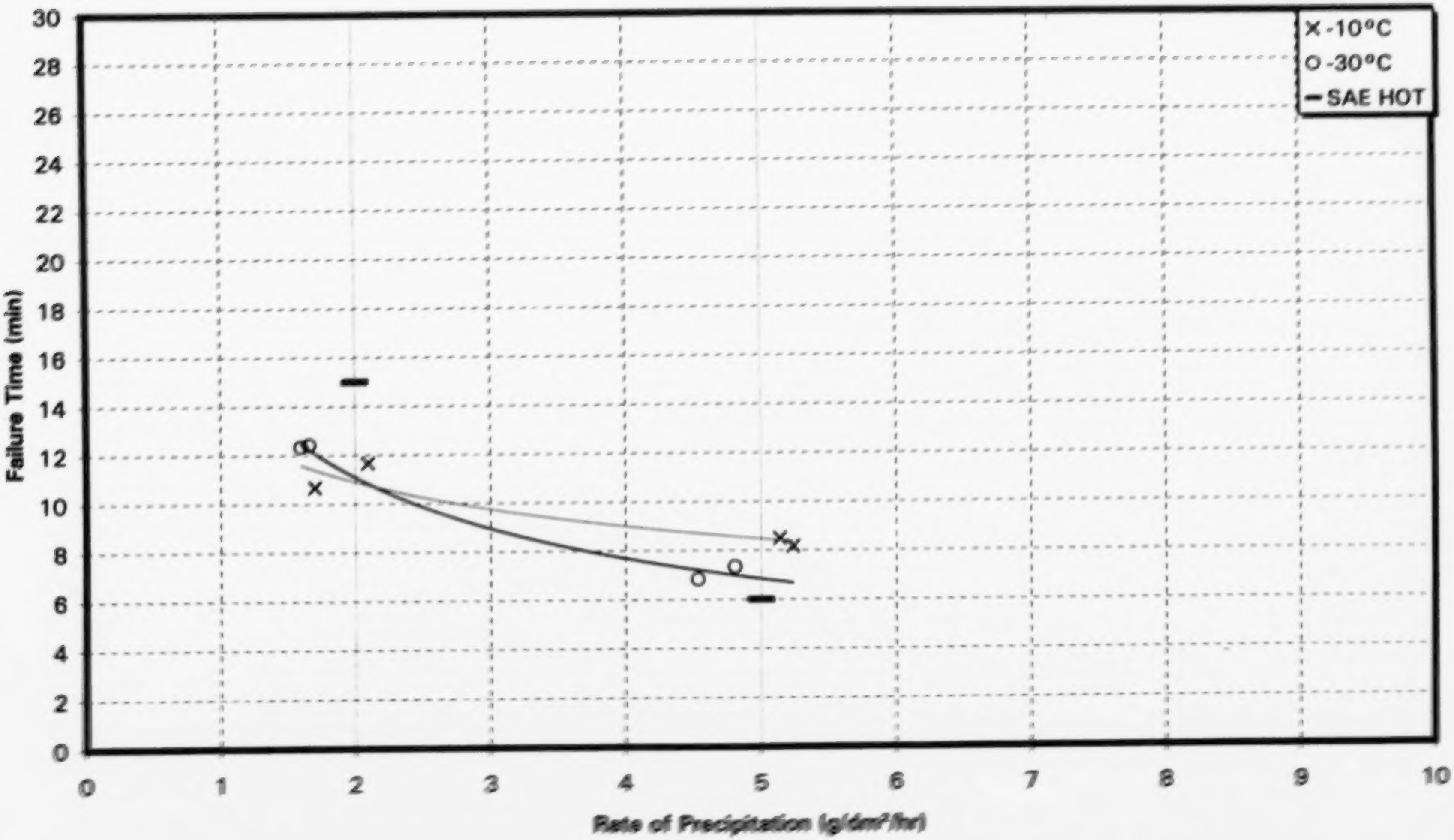
SIMULATED LIGHT FREEZING RAIN AT -10°C



EFFECT OF TEMPERATURE AND RATE OF PRECIPITATION ON ENDURANCE TIME

INLAND DURAGLY-P - TYPE I

SIMULATED FREEZING FOG

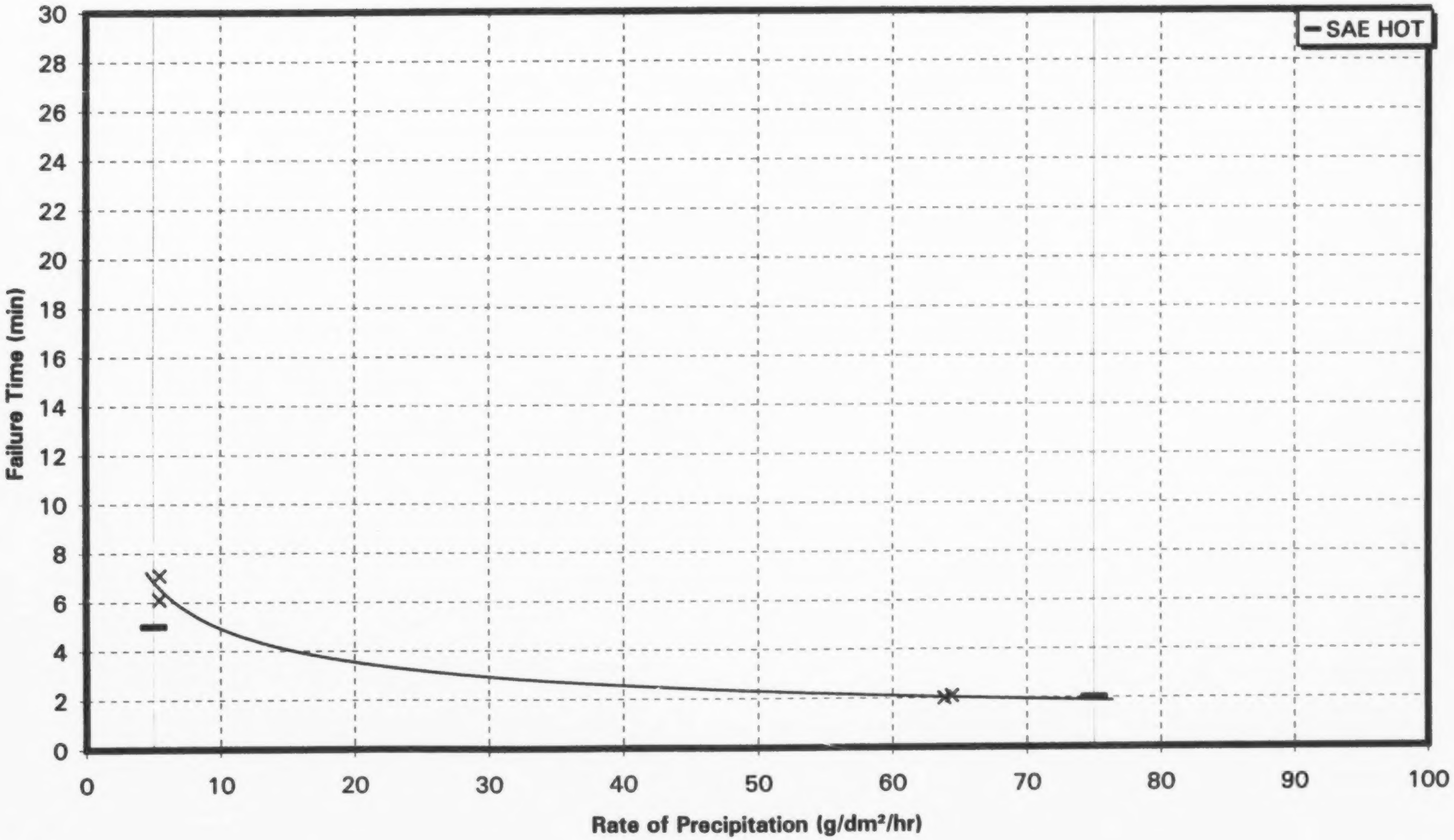


[illegible]

EFFECT OF RATE OF PRECIPITATION ON ENDURANCE TIME

INLAND DURAGLY-P - TYPE I

RAIN ON COLD-SOAK SURFACE

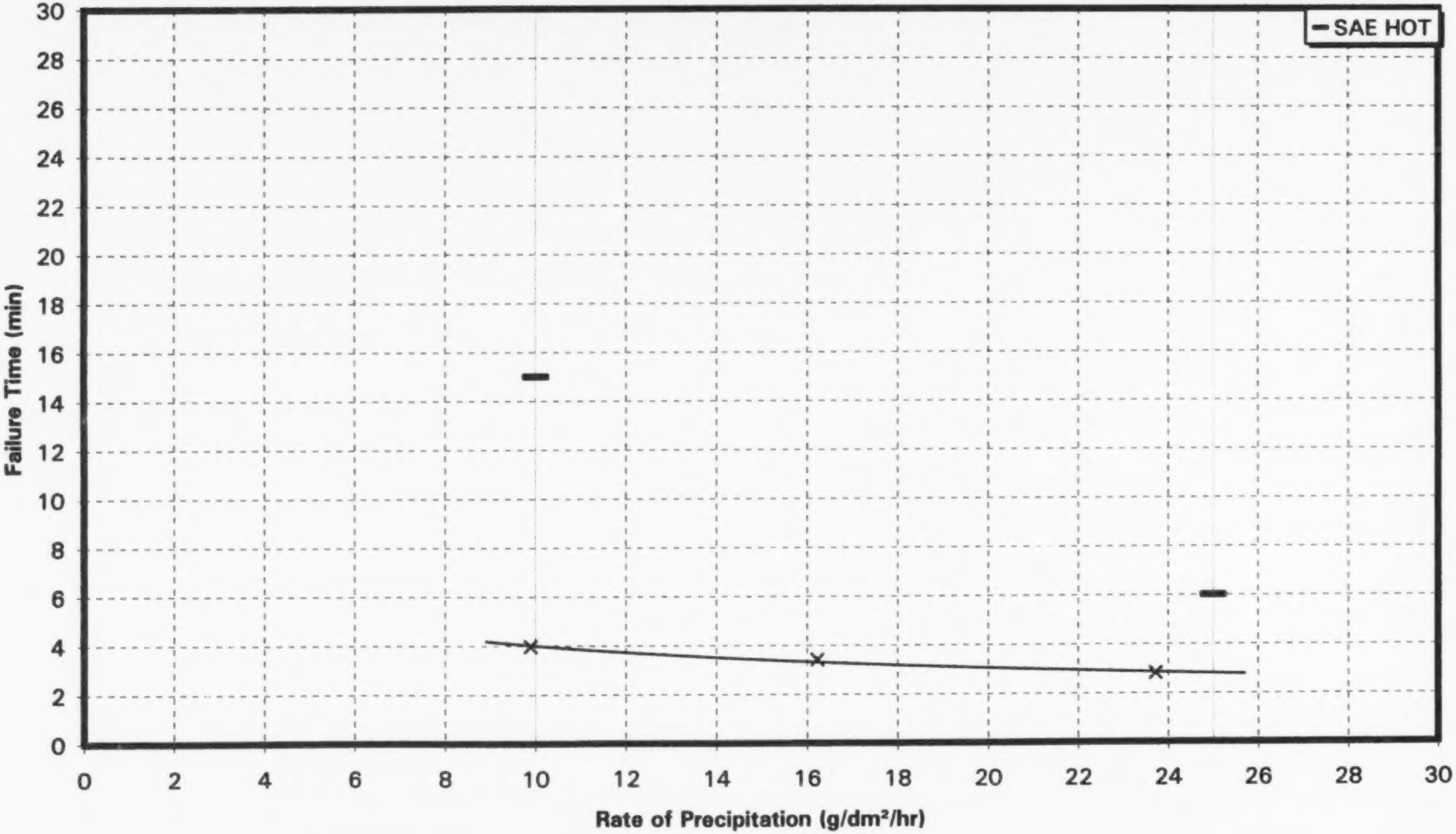


cm1514/analysis/type_1/charts/INLAND_P
At: CS

EFFECT OF RATE OF PRECIPITATION ON ENDURANCE TIME

INLAND DURAGLY-P - TYPE I

SIMULATED SNOW AT -10°C

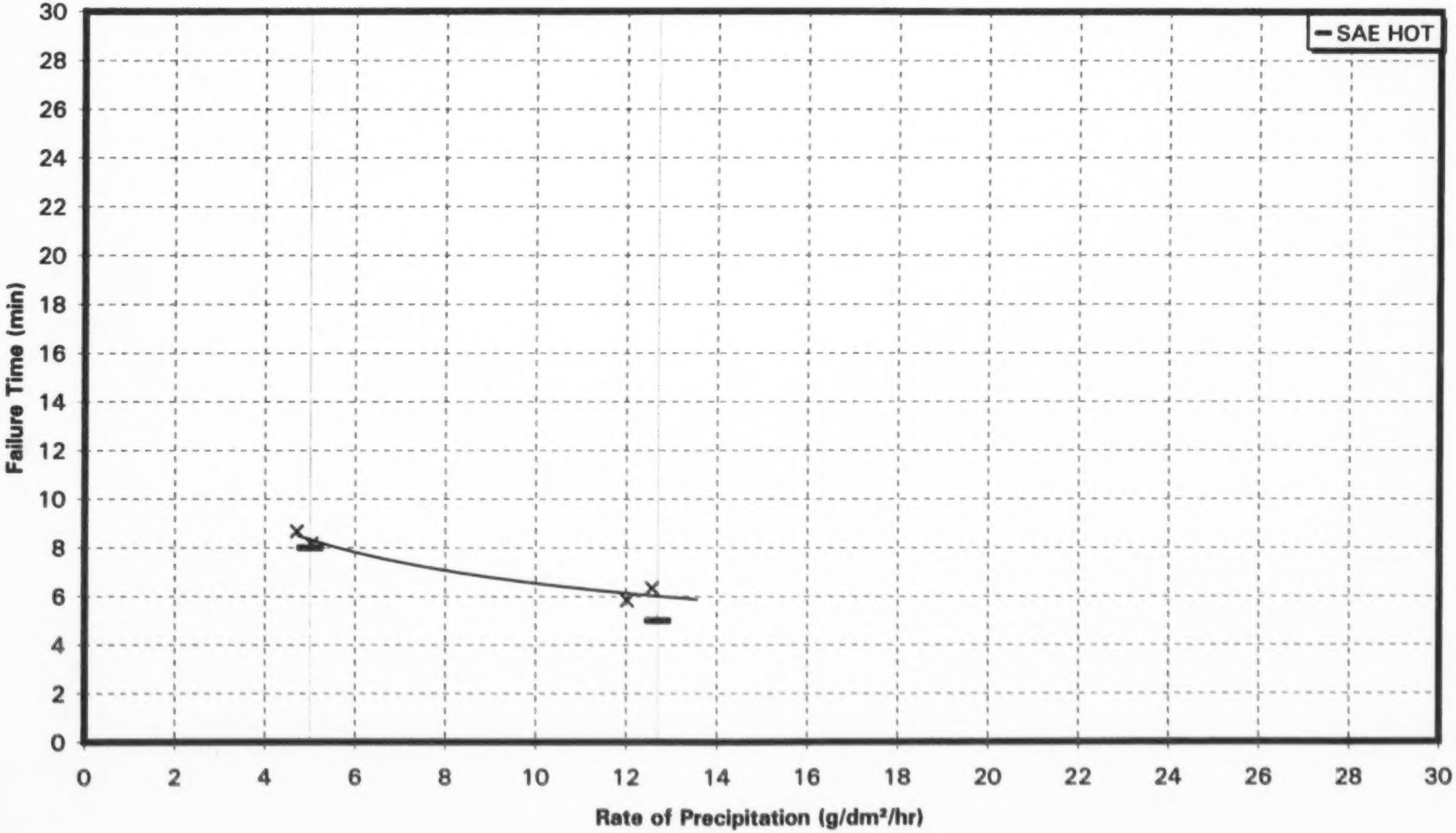


cm1514/analysis/type_1/charts/INLAND_P
At: Snow

EFFECT OF RATE OF PRECIPITATION ON ENDURANCE TIME

JAR KLEER - TYPE I

SIMULATED FREEZING DRIZZLE AT -10°C

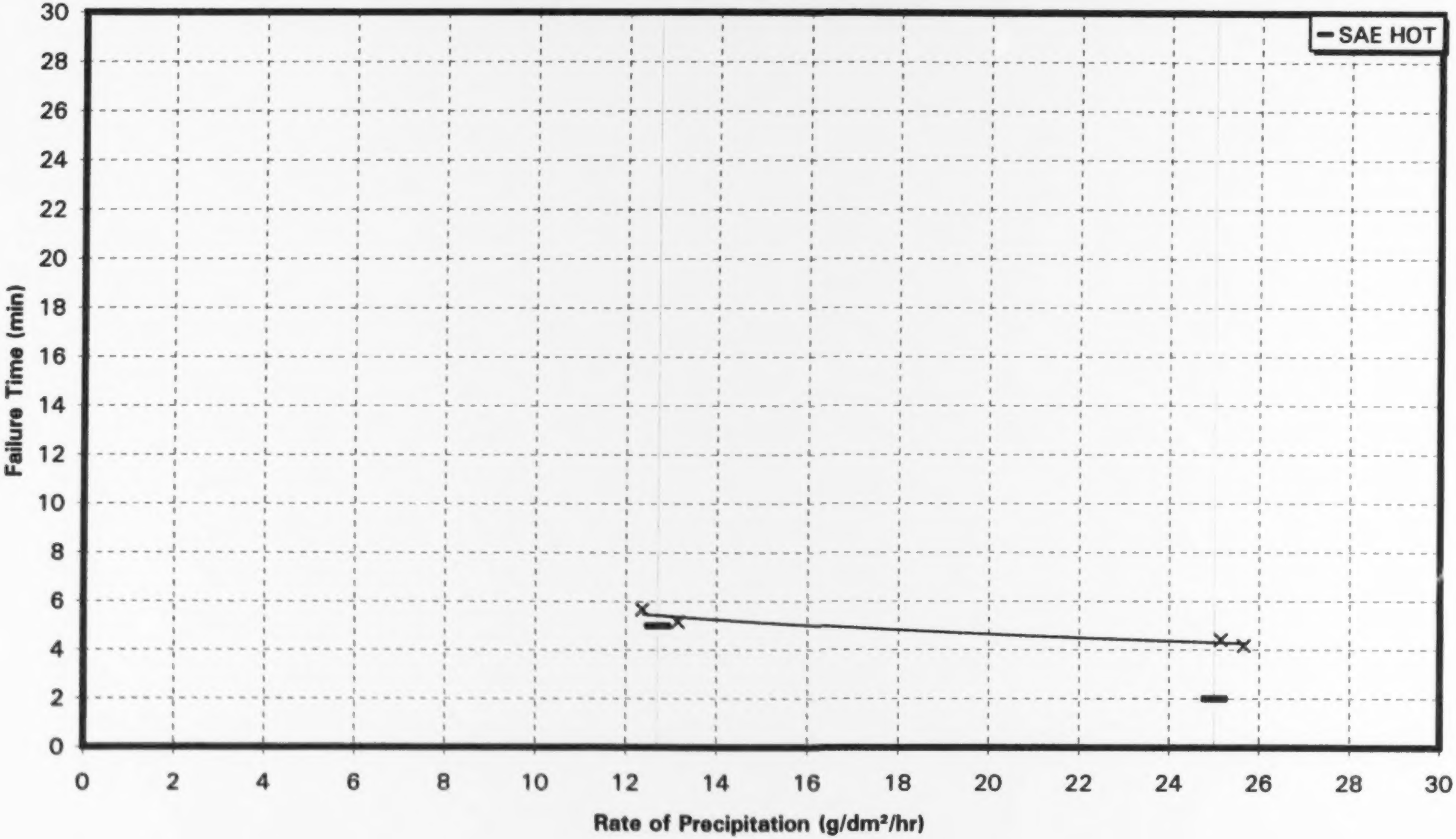


cm1514/analysis/type_1/charts/JARKLEER
At: ZD

EFFECT OF RATE OF PRECIPITATION ON ENDURANCE TIME

JAR KLEER - TYPE I

SIMULATED LIGHT FREEZING RAIN AT -10°C

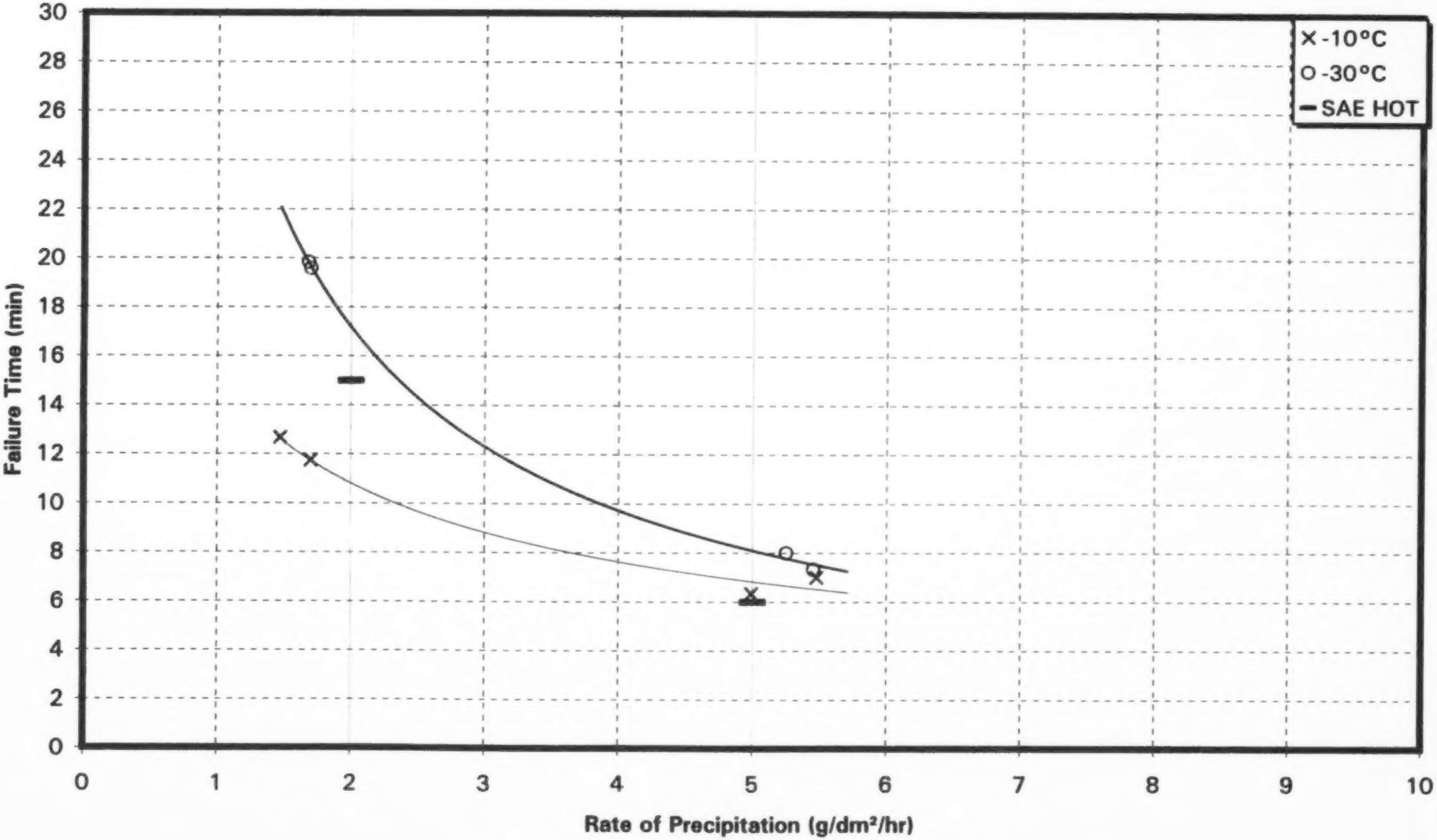


cm1514/analysis/type_1/charts/JARKLEER
At: ZR

EFFECT OF TEMPERATURE AND RATE OF PRECIPITATION ON ENDURANCE TIME

JAR KLEER - TYPE I

SIMULATED FREEZING FOG

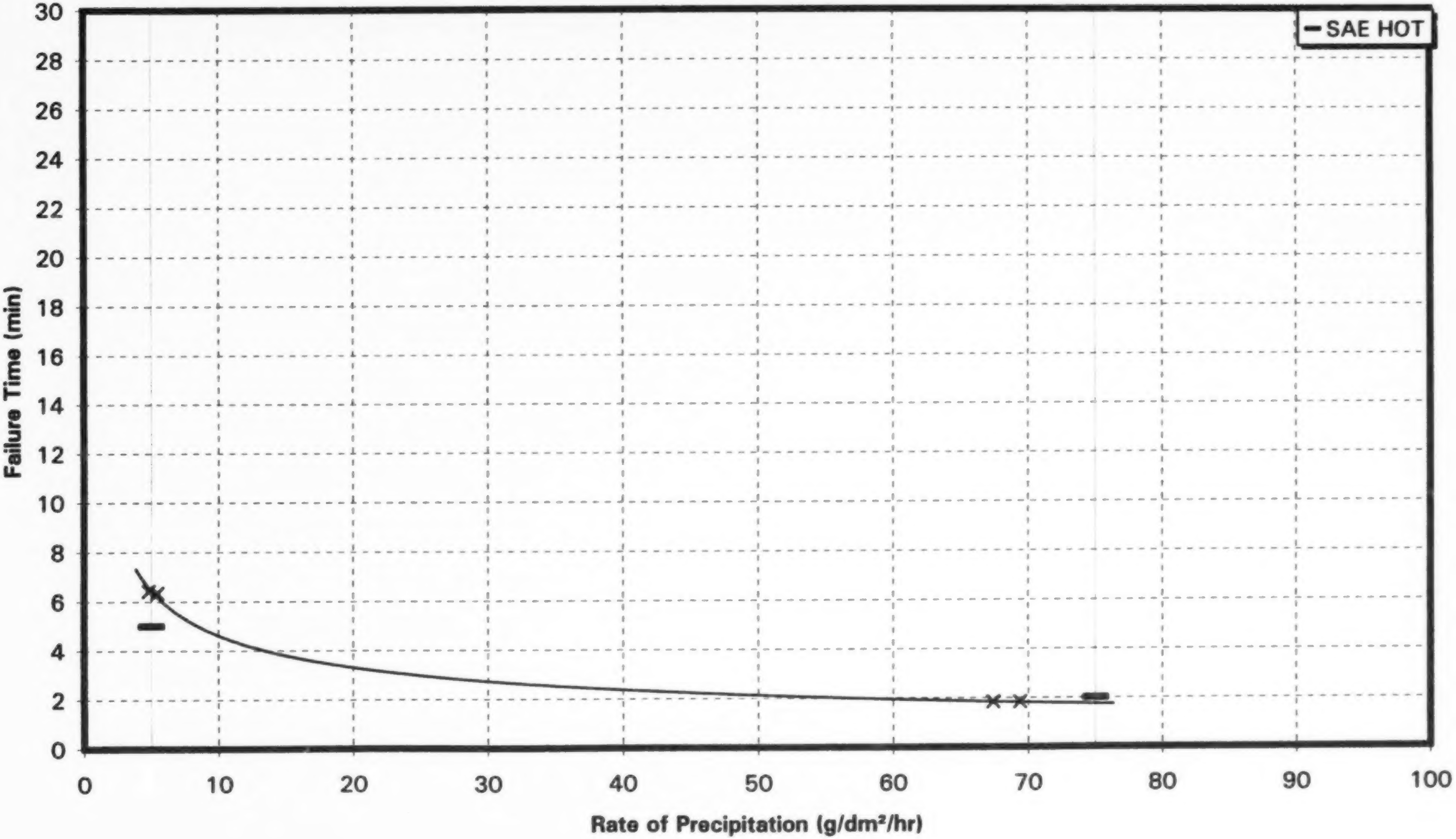


cm1514/analysis/type_1/charts/JARKLEER
At: ZF

EFFECT OF RATE OF PRECIPITATION ON ENDURANCE TIME

JAR KLEER - TYPE I

RAIN ON COLD-SOAK SURFACE

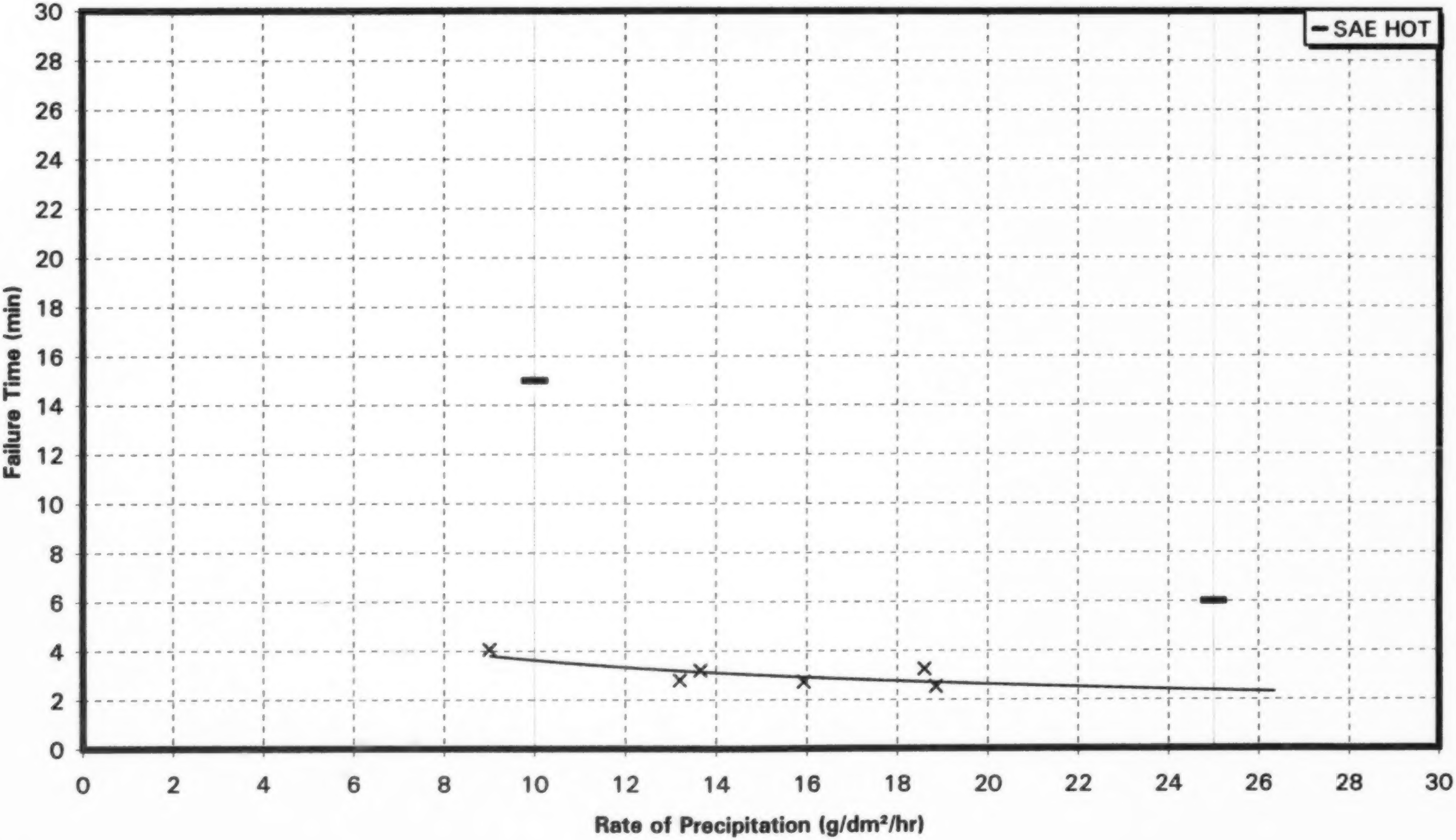


cm1514/analysis/type_1/charts/JARKLEER
At: CS

EFFECT OF RATE OF PRECIPITATION ON ENDURANCE TIME

JAR KLEER - TYPE I

SIMULATED SNOW AT -10°C

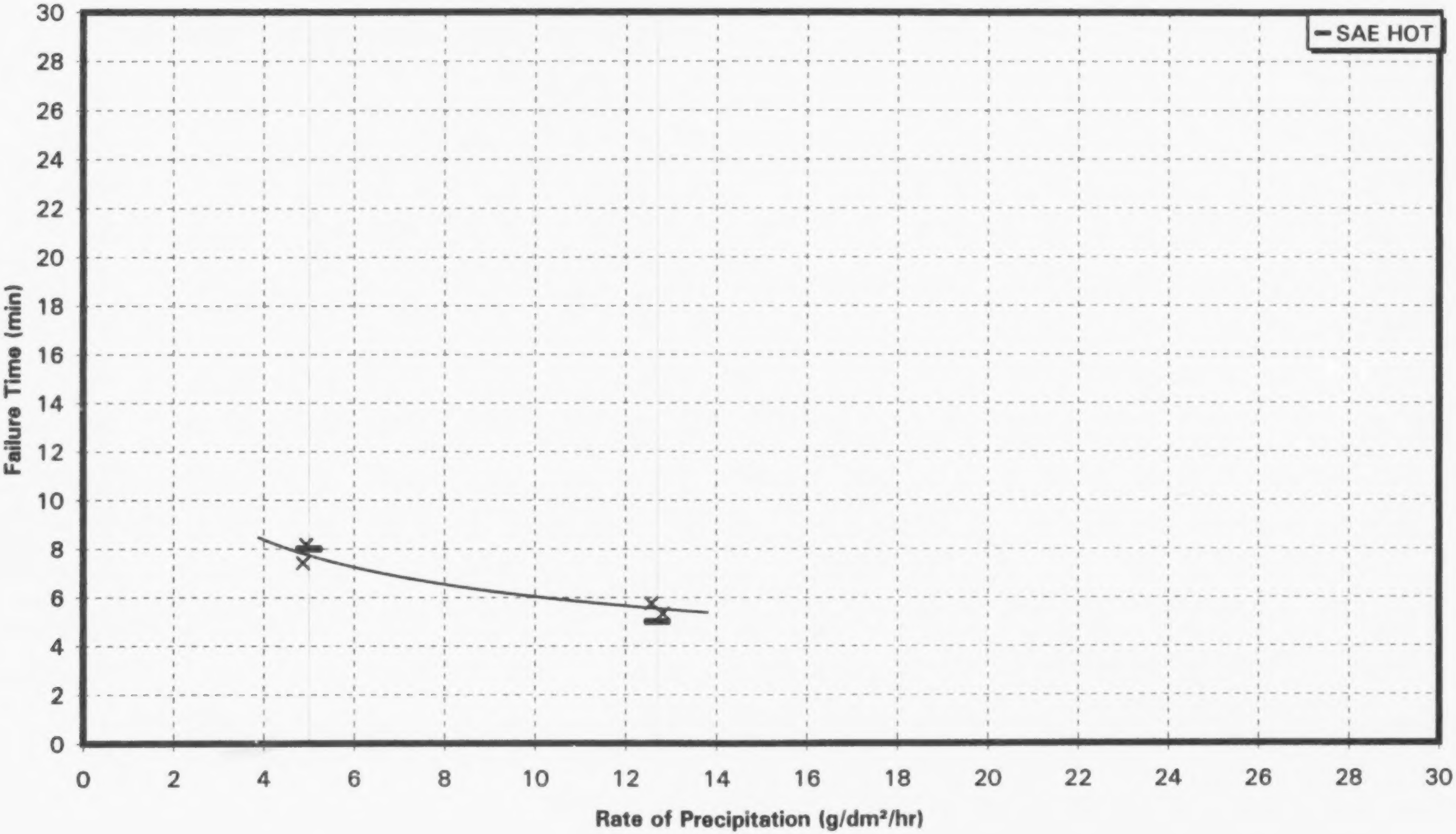


cm1514/analysis/type_1/charts/JARKLEER
At: Snow

EFFECT OF RATE OF PRECIPITATION ON ENDURANCE TIME

CLARIANT SAFEWING EG I 1996 - TYPE I

SIMULATED FREEZING DRIZZLE AT -10°C

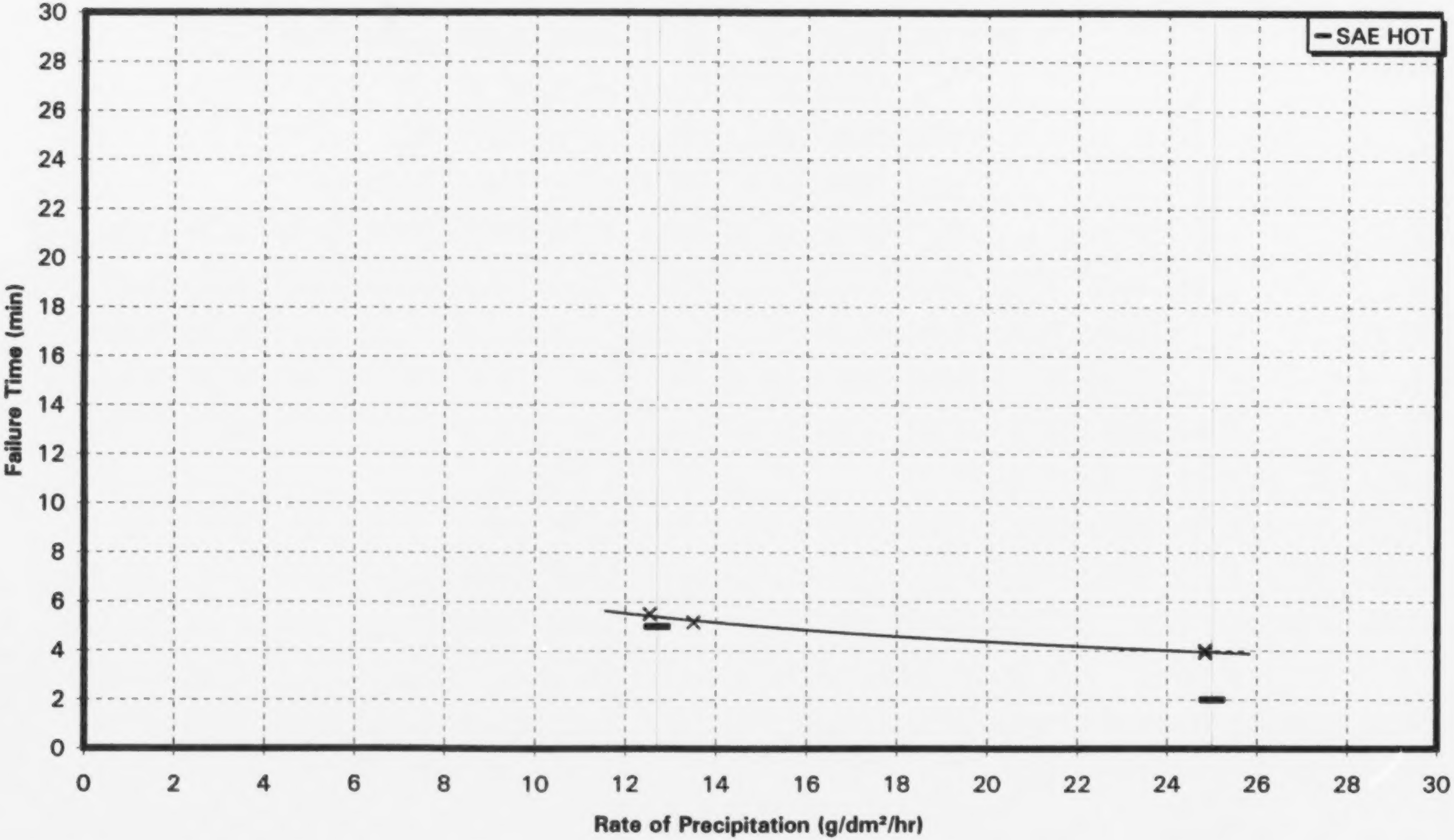


cm1514/analysis/type_1/charts/CLARIANT
At: ZD

EFFECT OF RATE OF PRECIPITATION ON ENDURANCE TIME

CLARIANT SAFEWING EG I 1996 - TYPE I

SIMULATED LIGHT FREEZING RAIN AT -10°C

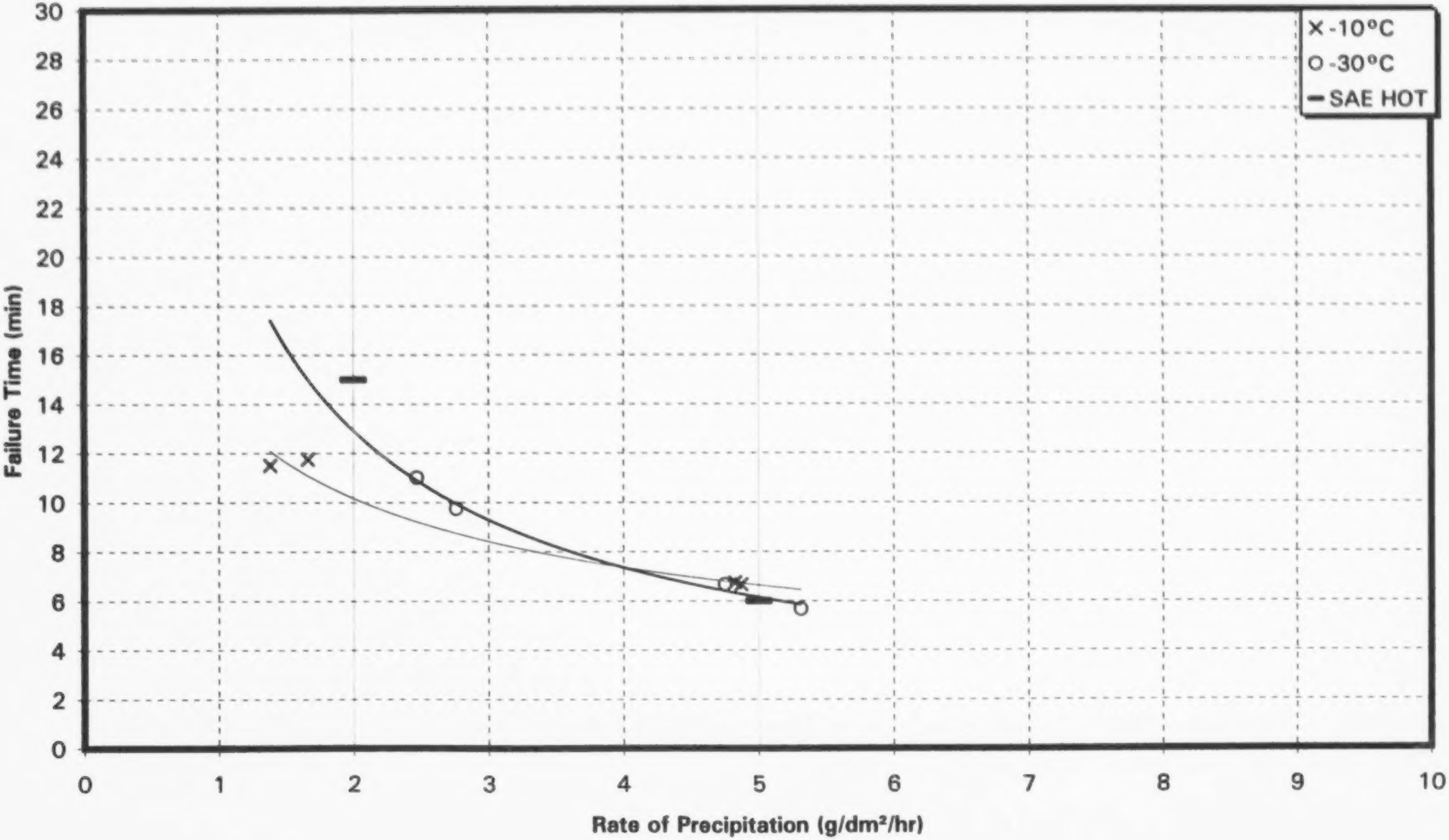


cm1514/analysis/type_1/charts/CLARIANT
At: ZR

EFFECT OF TEMPERATURE AND RATE OF PRECIPITATION ON ENDURANCE TIME

CLARIANT SAFEWING EG I 1996 - TYPE I

SIMULATED FREEZING FOG

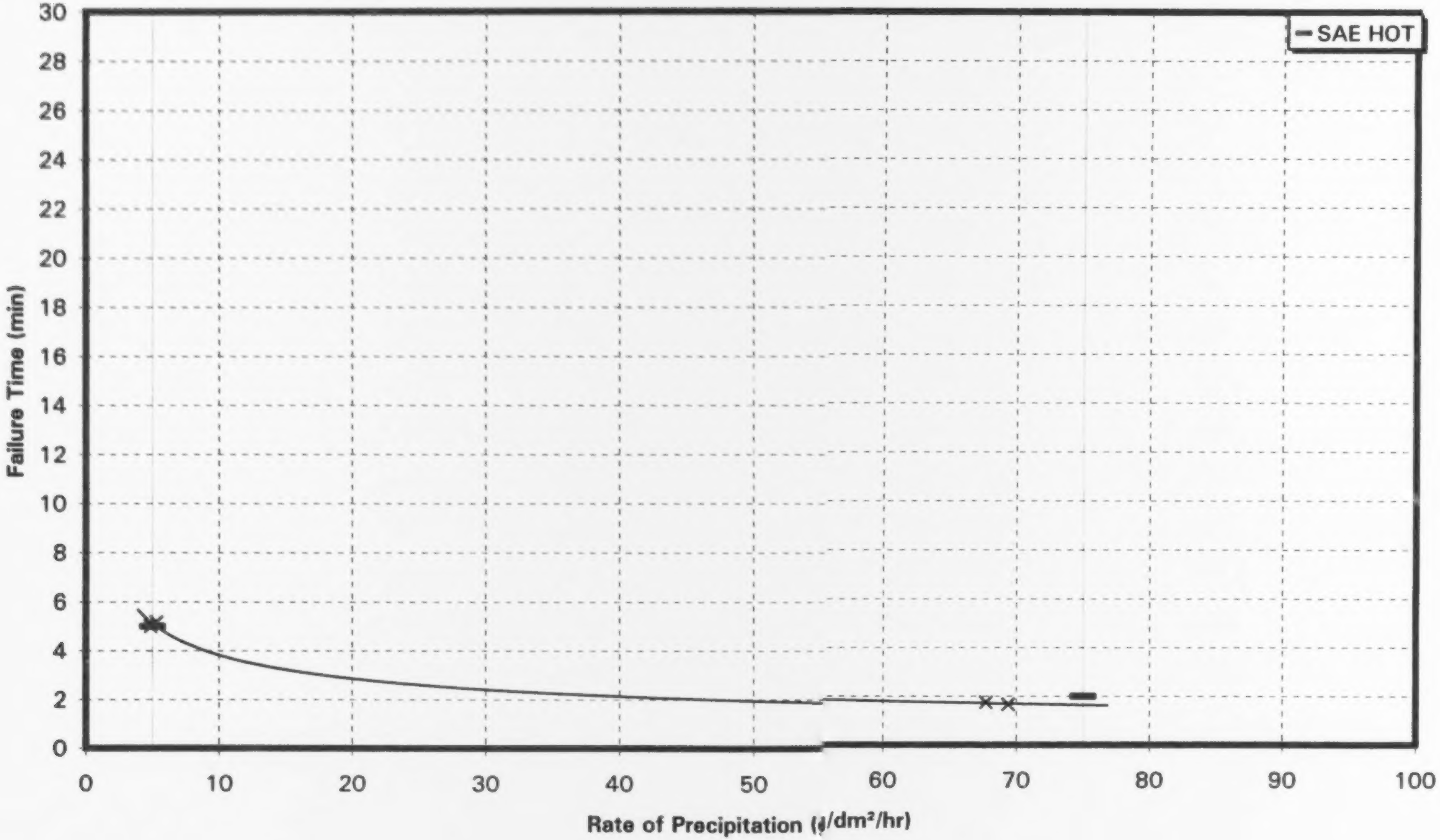


cm1514/analysis/type_1/charts/CLARIANT
At: ZF

EFFECT OF RATE OF PRECIPITATION ON ENDURANCE TIME

CLARIANT SAFEWING EG I 1996 - TYPE I

RAIN ON COLD-SOAK SURFACE



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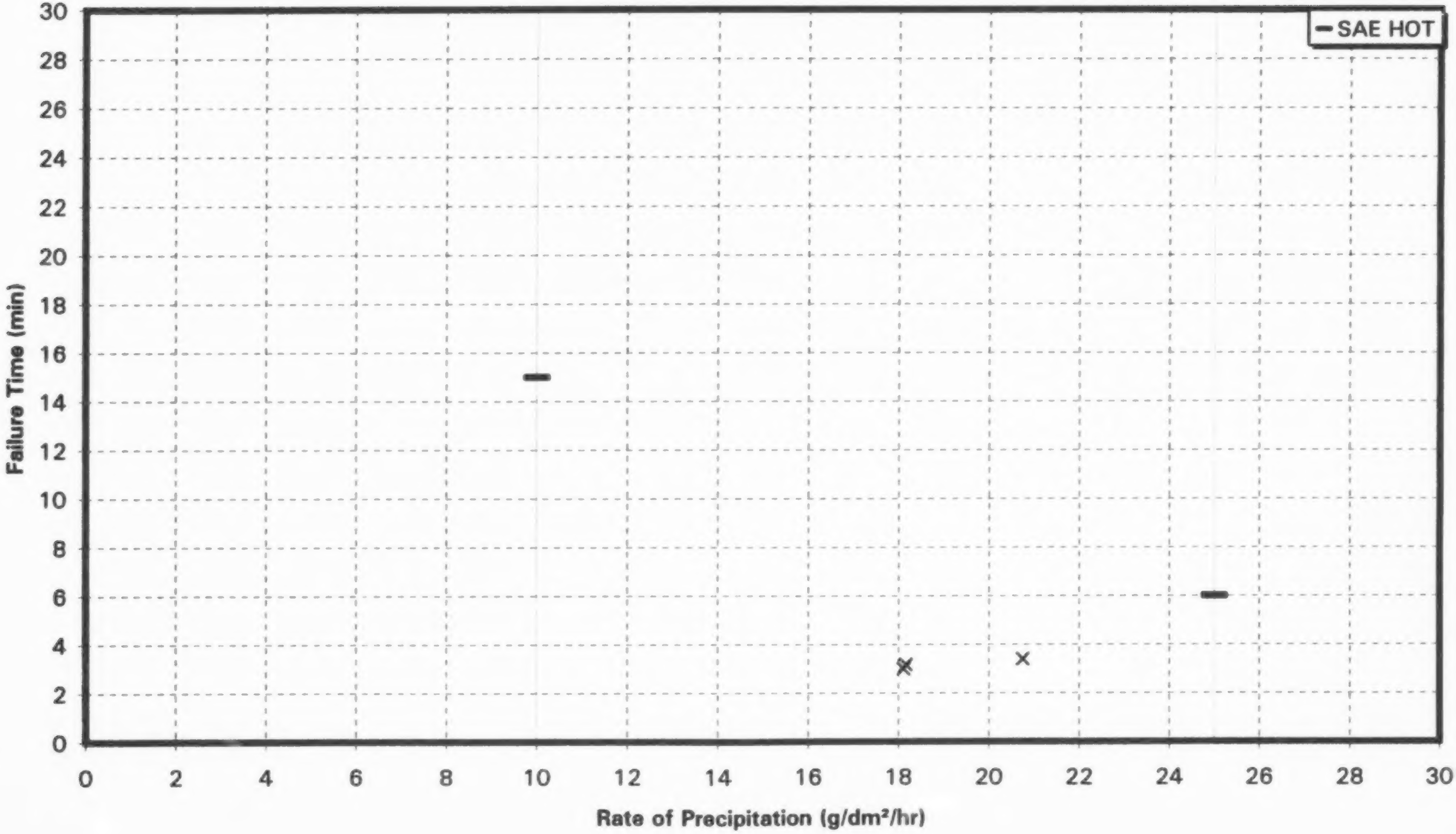
At: CS

EFFECT OF RATE OF PRECIPITATION ON ENDURANCE TIME

CLARIANT SAFEWING EG I 1996 - TYPE I

SIMULATED SNOW AT -10°C

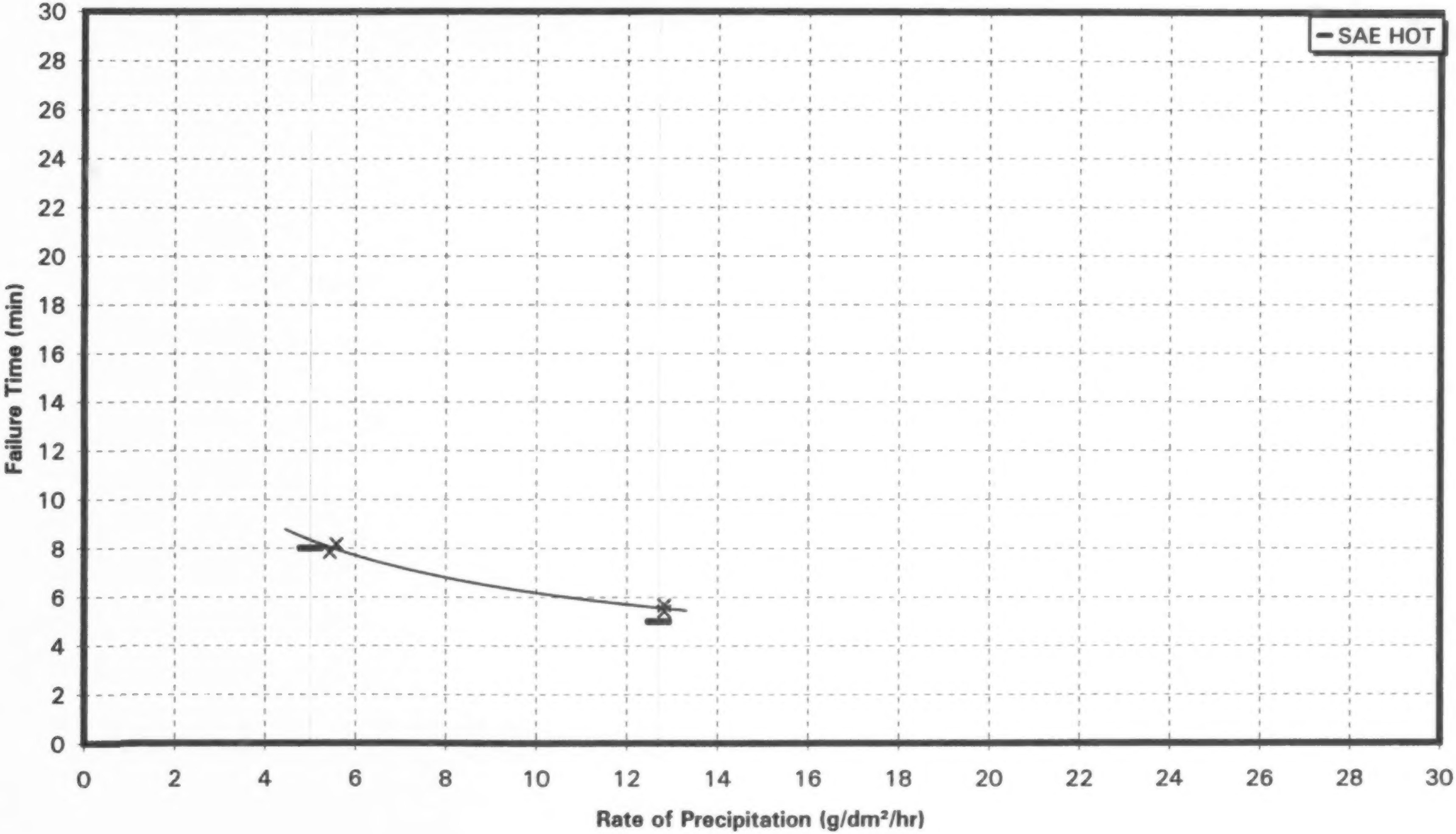


cm1514/analysis/type_1/charts/CLARIANT
At: Snow

EFFECT OF RATE OF PRECIPITATION ON ENDURANCE TIME

OCTAFLO - TYPE I

SIMULATED FREEZING DRIZZLE AT -10°C

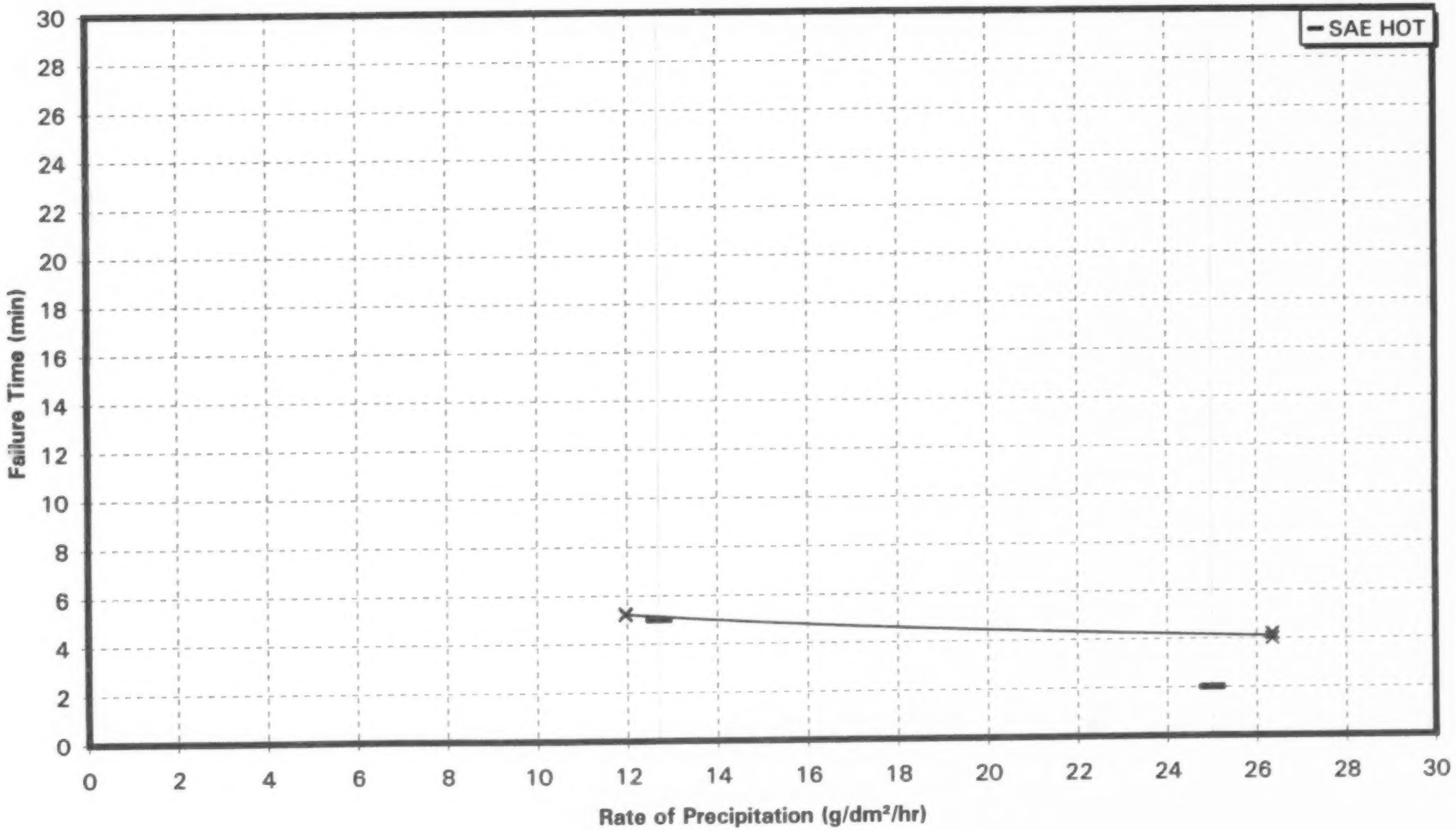


cm1514/analysis/type_1/charts/OCTAFLO
At: ZD

EFFECT OF RATE OF PRECIPITATION ON ENDURANCE TIME

OCTAFLO - TYPE I

SIMULATED LIGHT FREEZING RAIN AT -10°C

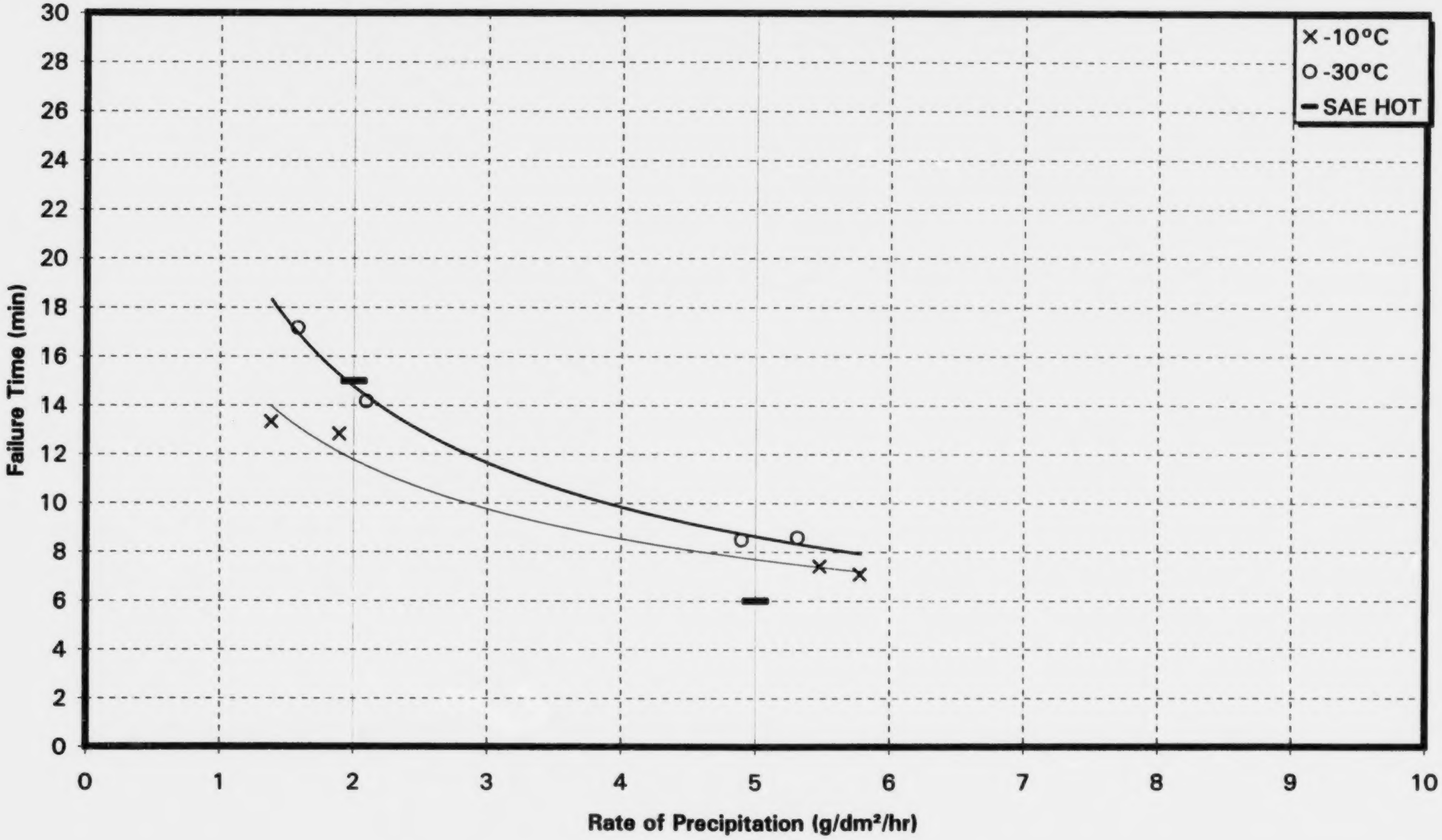


cm1514/analysis/type_1/charts/OCTAFLO
At: ZR

EFFECT OF TEMPERATURE AND RATE OF PRECIPITATION ON ENDURANCE TIME

OCTAFLO - TYPE I

SIMULATED FREEZING FOG

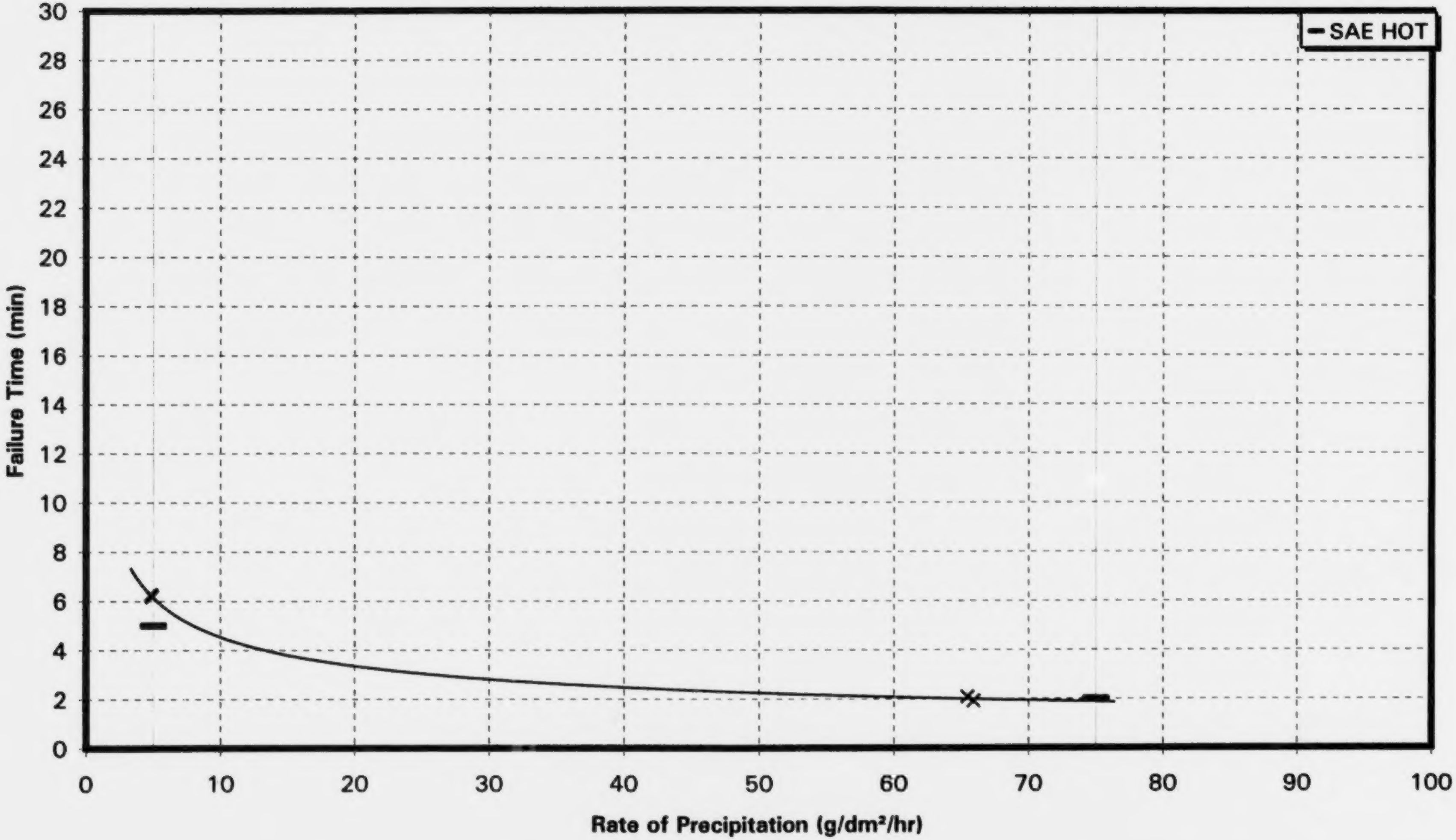


cm1514/analysis/type_1/charts/OCTAFLO
At: ZF

EFFECT OF RATE OF PRECIPITATION ON ENDURANCE TIME

OCTAFLO - TYPE I

RAIN ON COLD-SOAK SURFACE

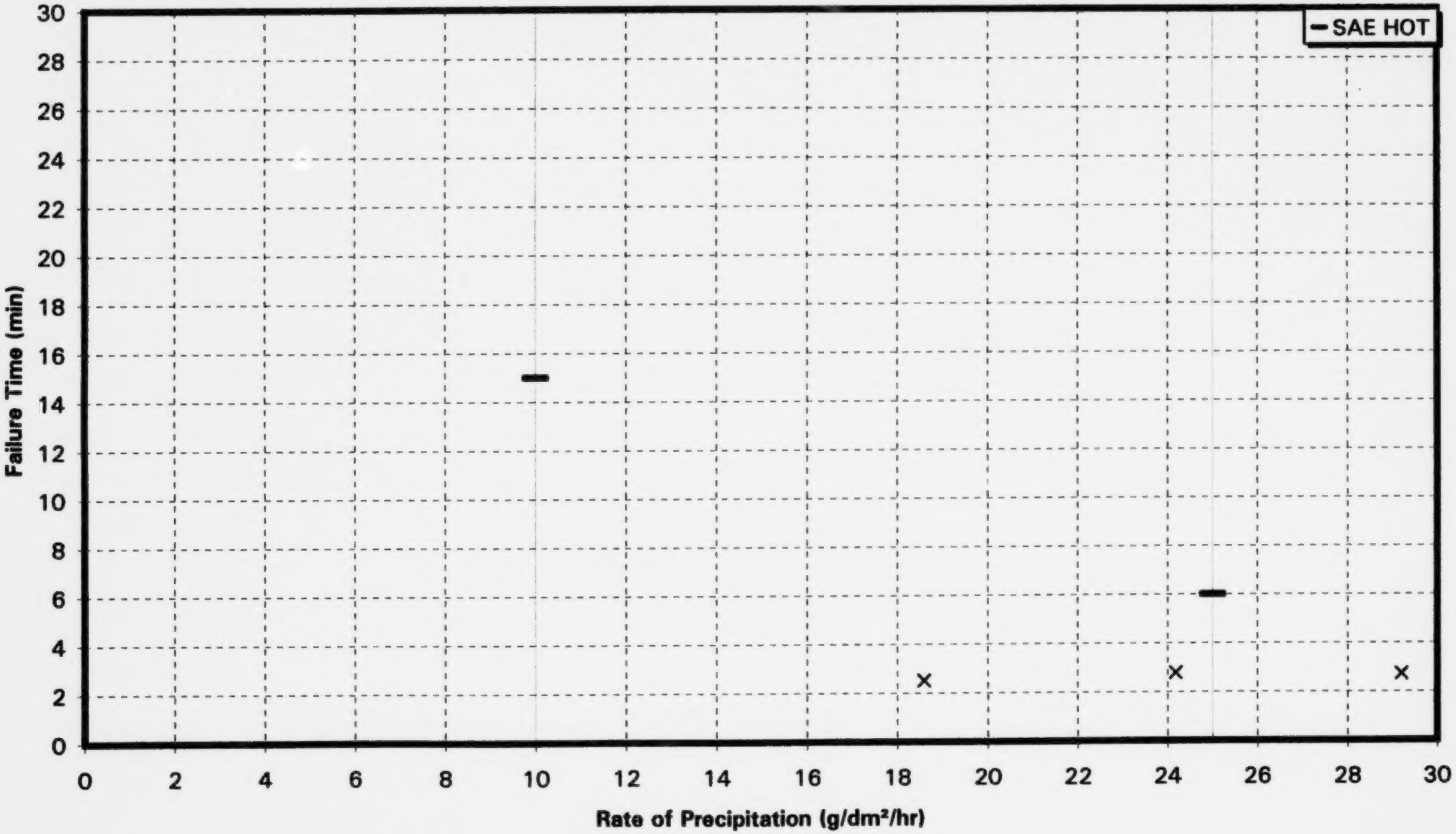


cm1514/analysis/type_1/charts/OCTAFLO
At: CS

EFFECT OF RATE OF PRECIPITATION ON ENDURANCE TIME

OCTAFLO - TYPE I

SIMULATED SNOW AT -10°C

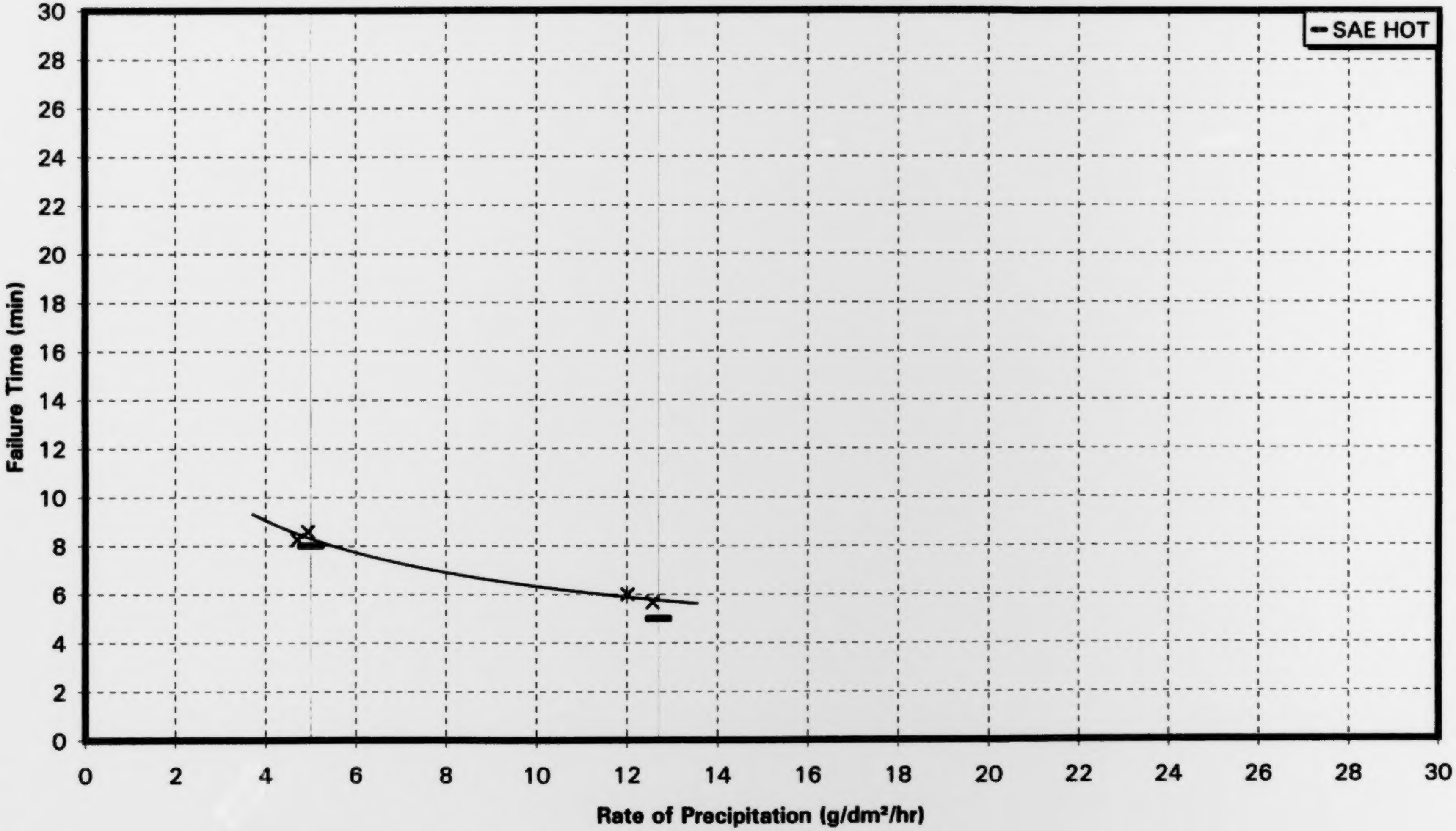


cm1514/analysis/type_1/charts/OCTAFLO
At: Snow

EFFECT OF RATE OF PRECIPITATION ON ENDURANCE TIME

UCAR ADF - TYPE I

SIMULATED FREEZING DRIZZLE AT -10°C

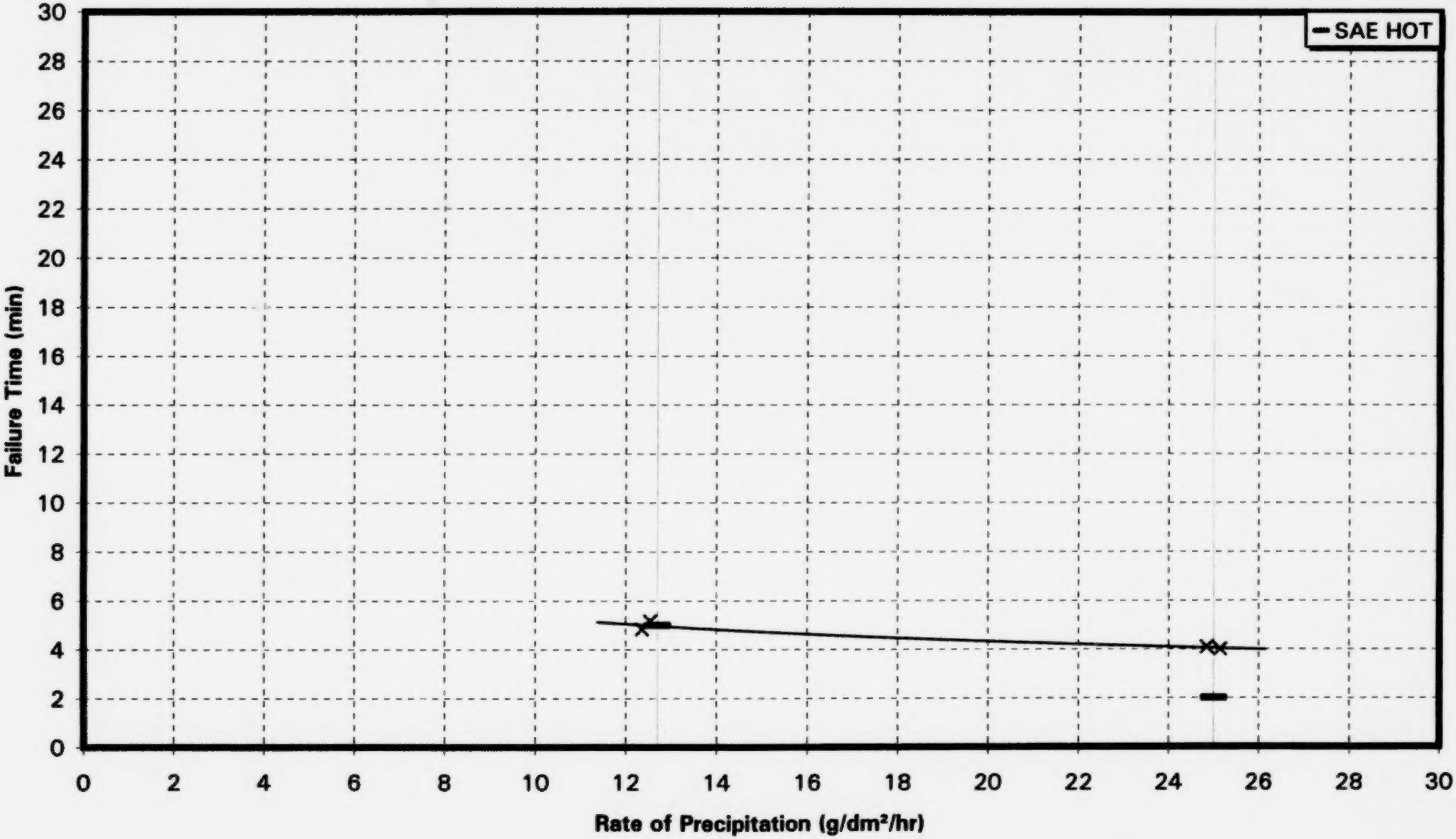


cm1514/analysis/type_1/charts/UCAR_ADF
At: ZD

EFFECT OF RATE OF PRECIPITATION ON ENDURANCE TIME

UCAR ADF - TYPE I

SIMULATED LIGHT FREEZING RAIN AT -10°C



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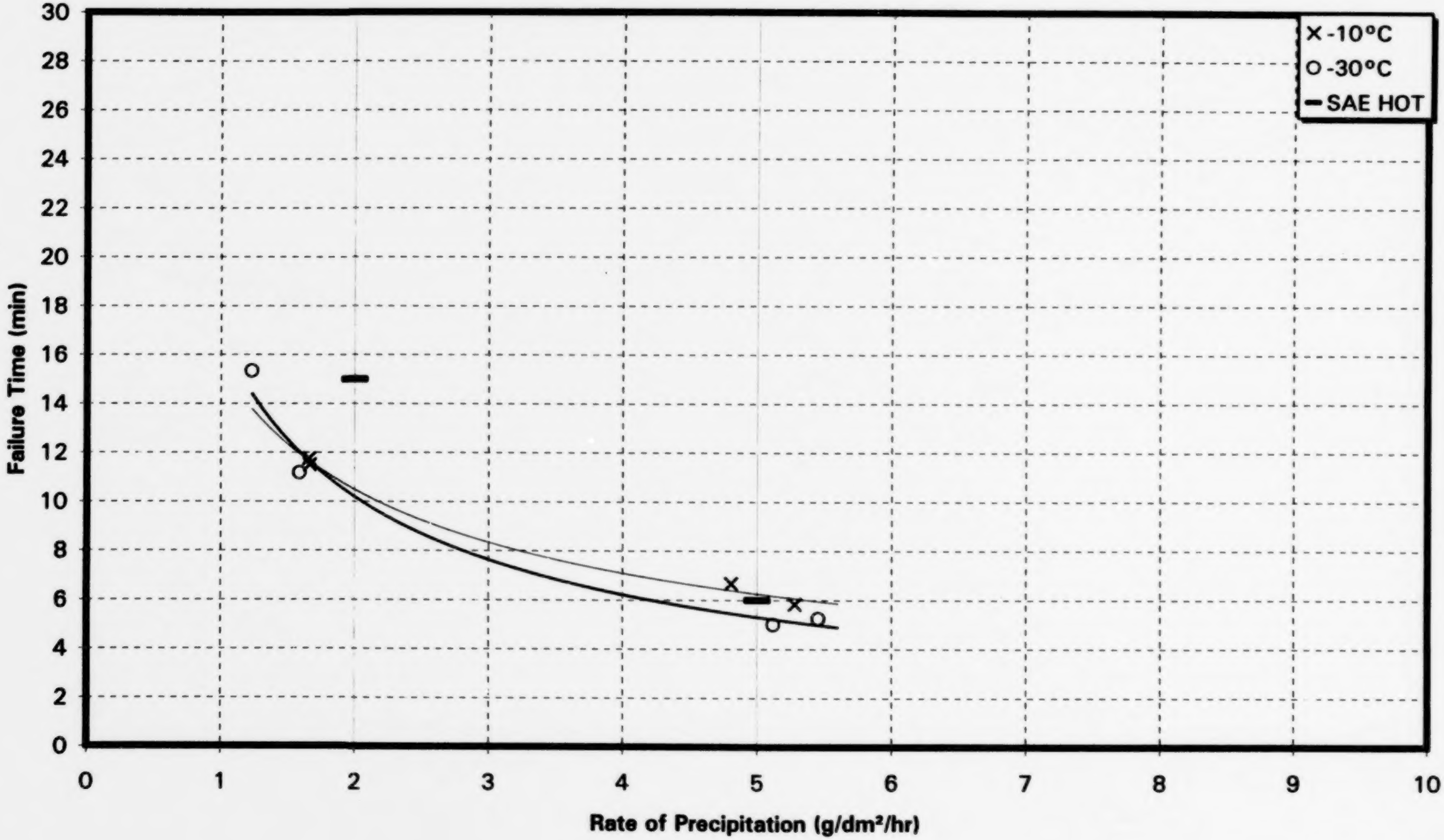
At: ZR

EFFECT OF TEMPERATURE AND RATE OF PRECIPITATION ON ENDURANCE TIME

UCAR ADF - TYPE I

SIMULATED FREEZING FOG

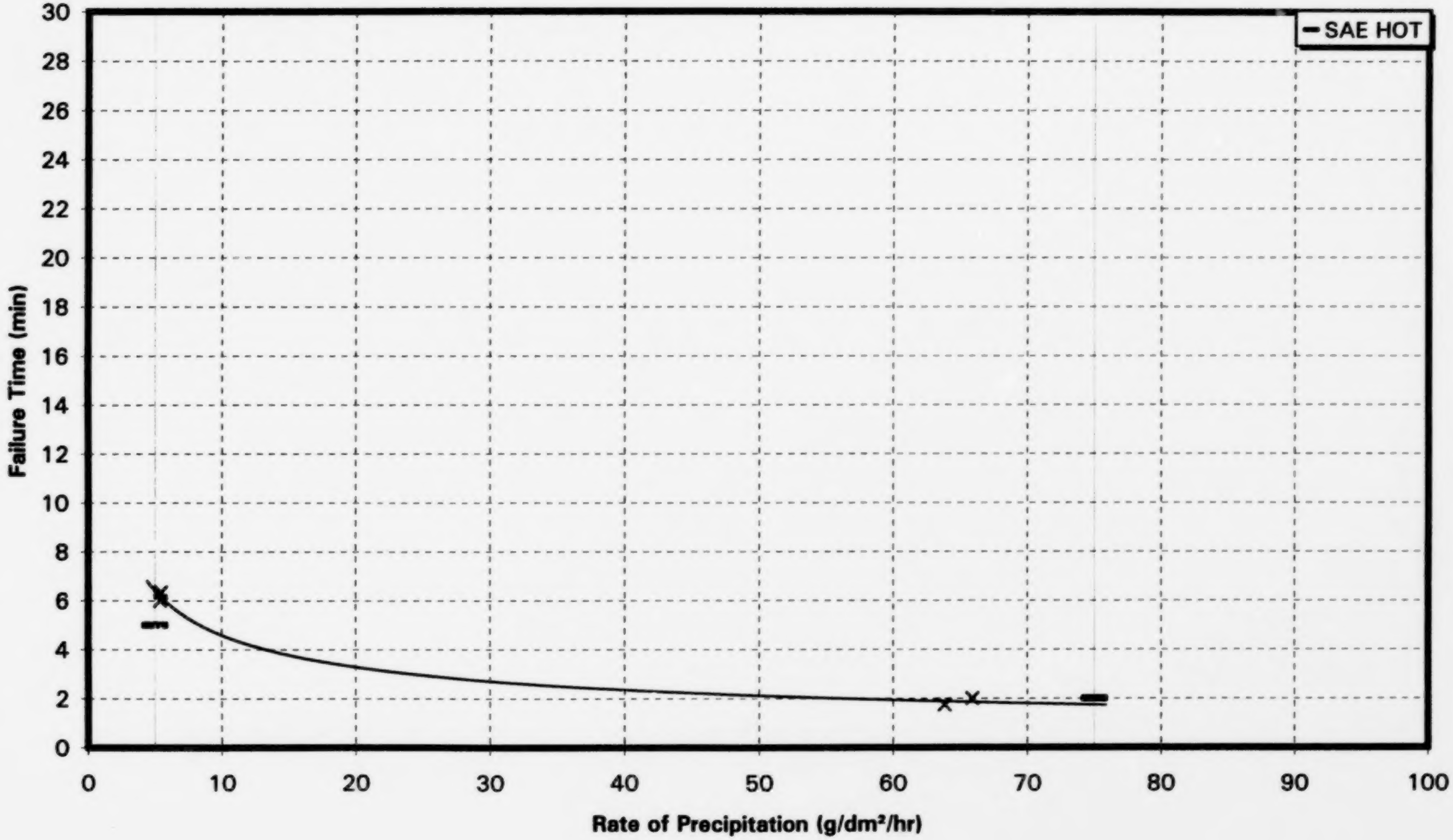


cm1514/analysis/type_1/charts/UCAR_ADF
At: ZF

EFFECT OF RATE OF PRECIPITATION ON ENDURANCE TIME

UCAR ADF - TYPE I

RAIN ON COLD-SOAK SURFACE

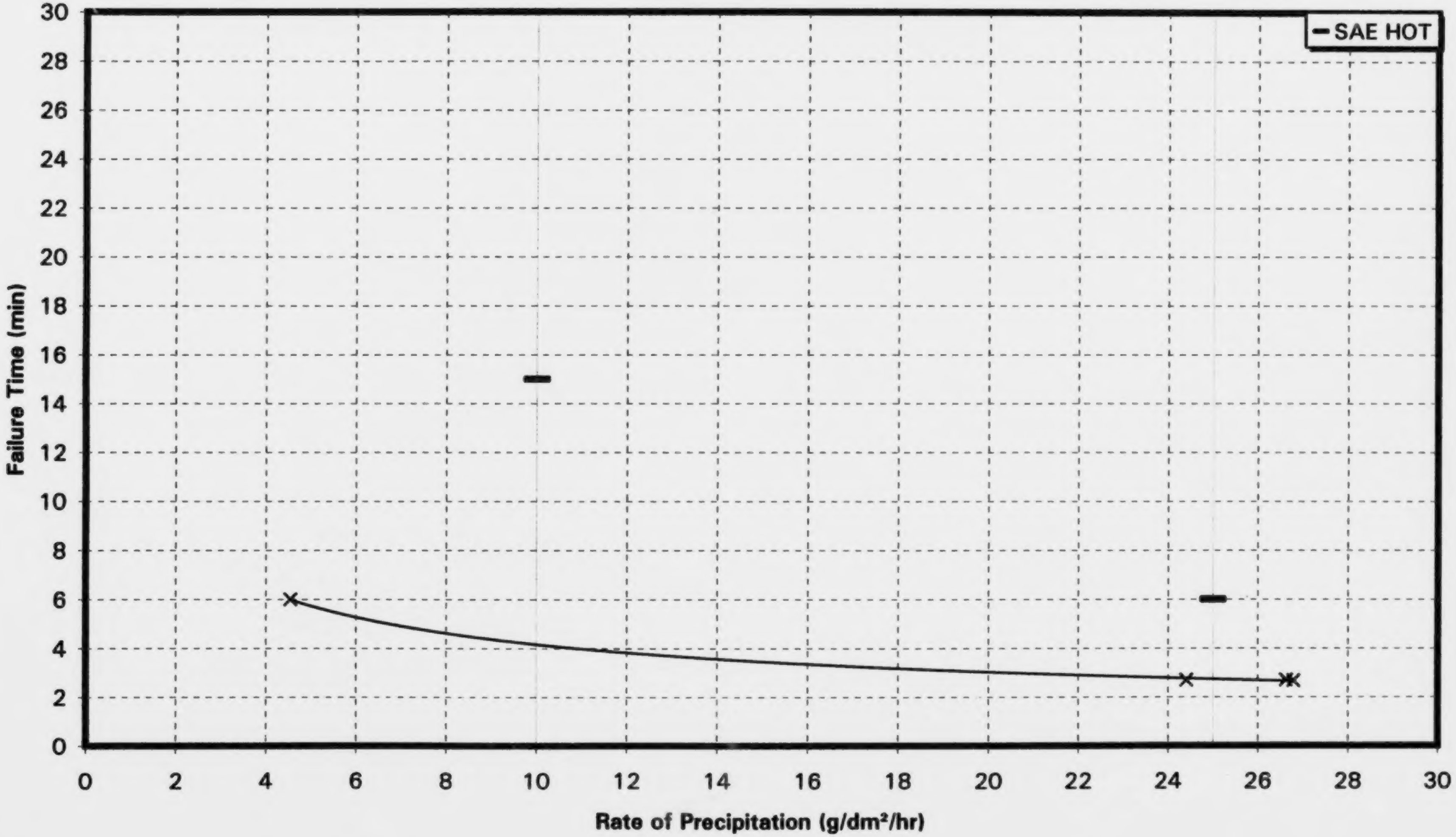


cm1514/analysis/type_1/charts/UCAR_ADF
At: CS

EFFECT OF RATE OF PRECIPITATION ON ENDURANCE TIME

UCAR ADF - TYPE I

SIMULATED SNOW AT -10°C

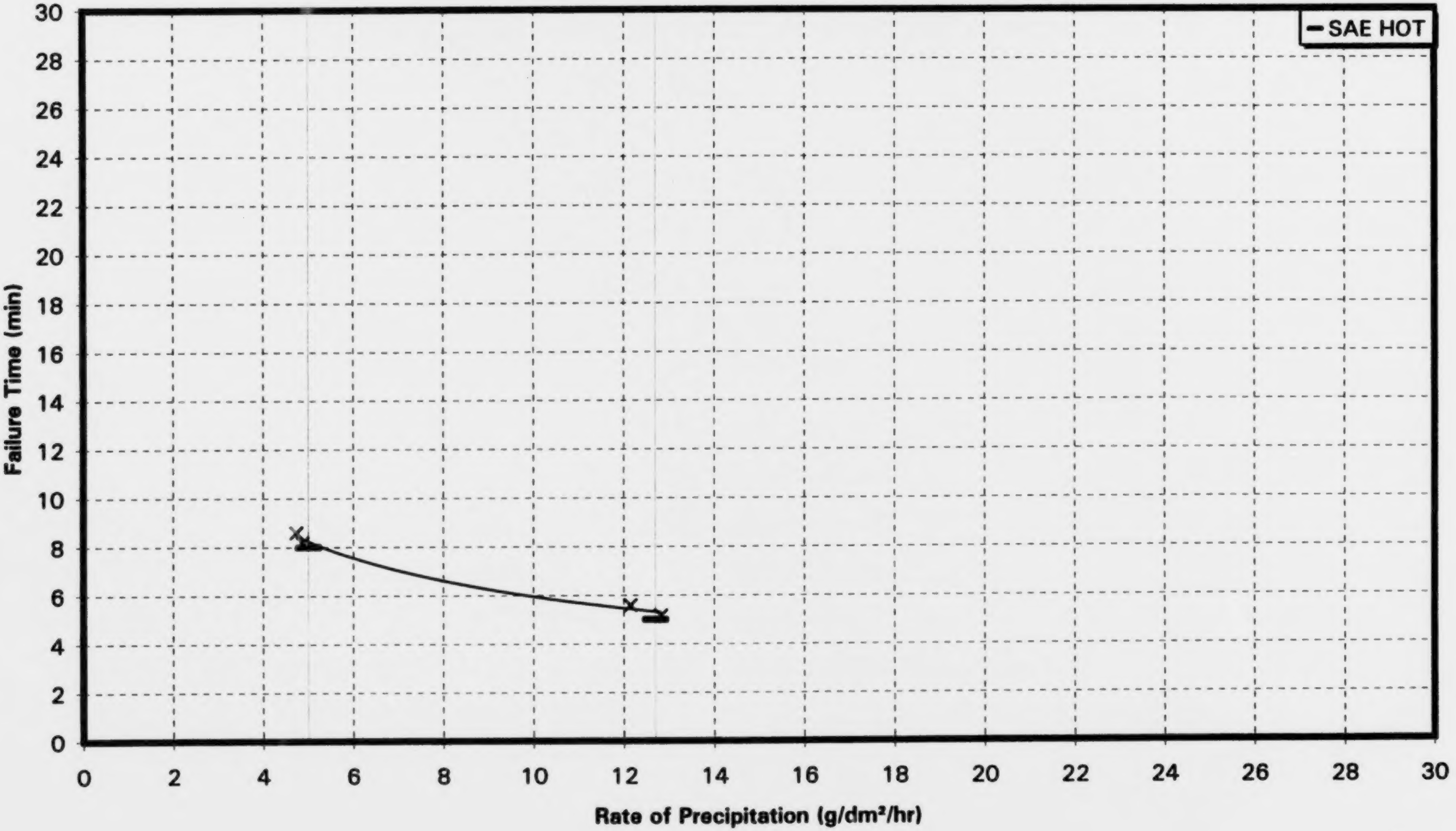


cm1514/analysis/type_1/charts/UCAR_ADF
At: Snow

EFFECT OF RATE OF PRECIPITATION ON ENDURANCE TIME

OCTAFLO EF - TYPE I

SIMULATED FREEZING DRIZZLE AT -10°C

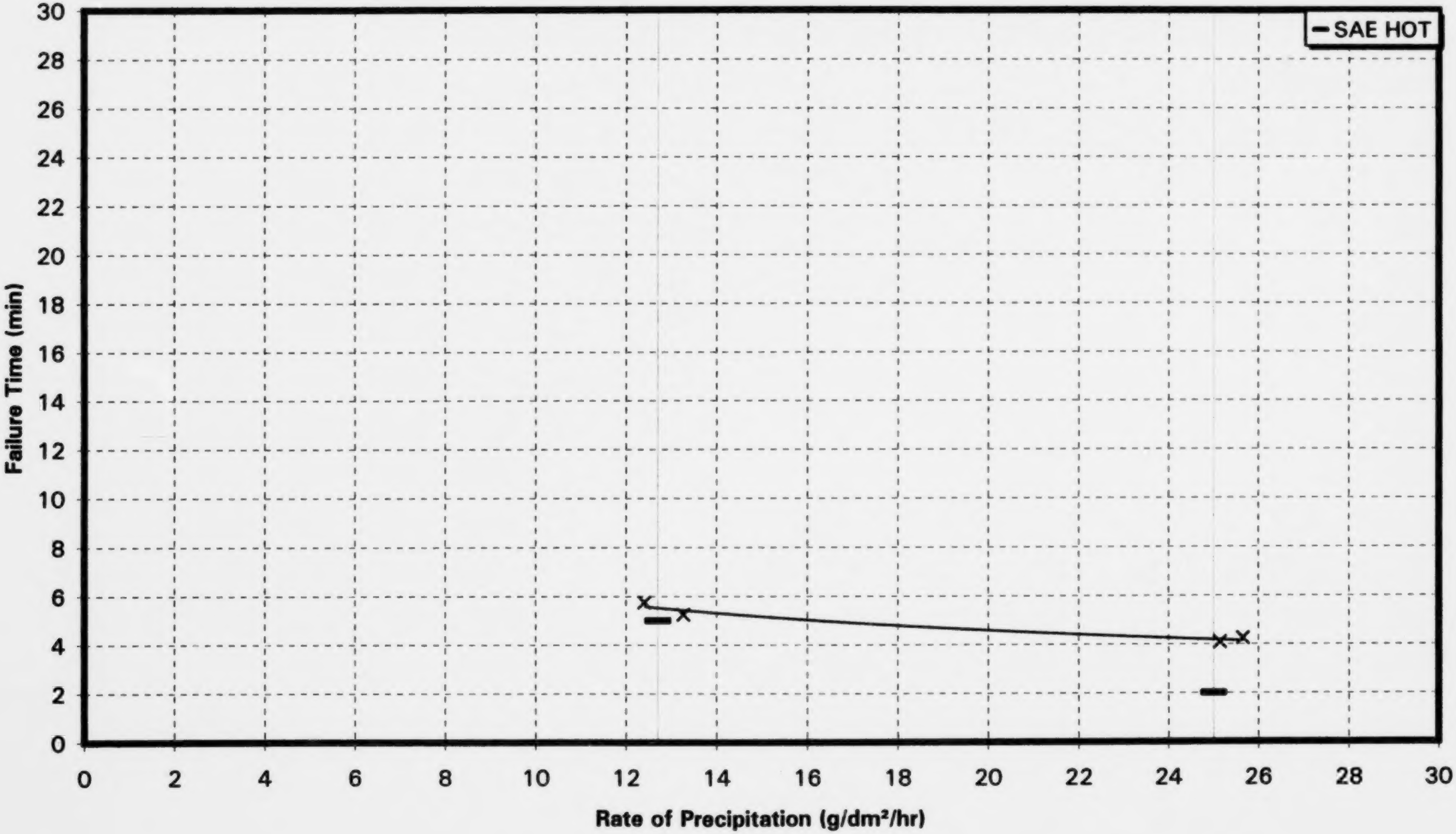


cm1514/analysis/type_1/charts/OCT_EF
At: ZD

EFFECT OF RATE OF PRECIPITATION ON ENDURANCE TIME

OCTAFLO EF - TYPE I

SIMULATED LIGHT FREEZING RAIN AT -10°C

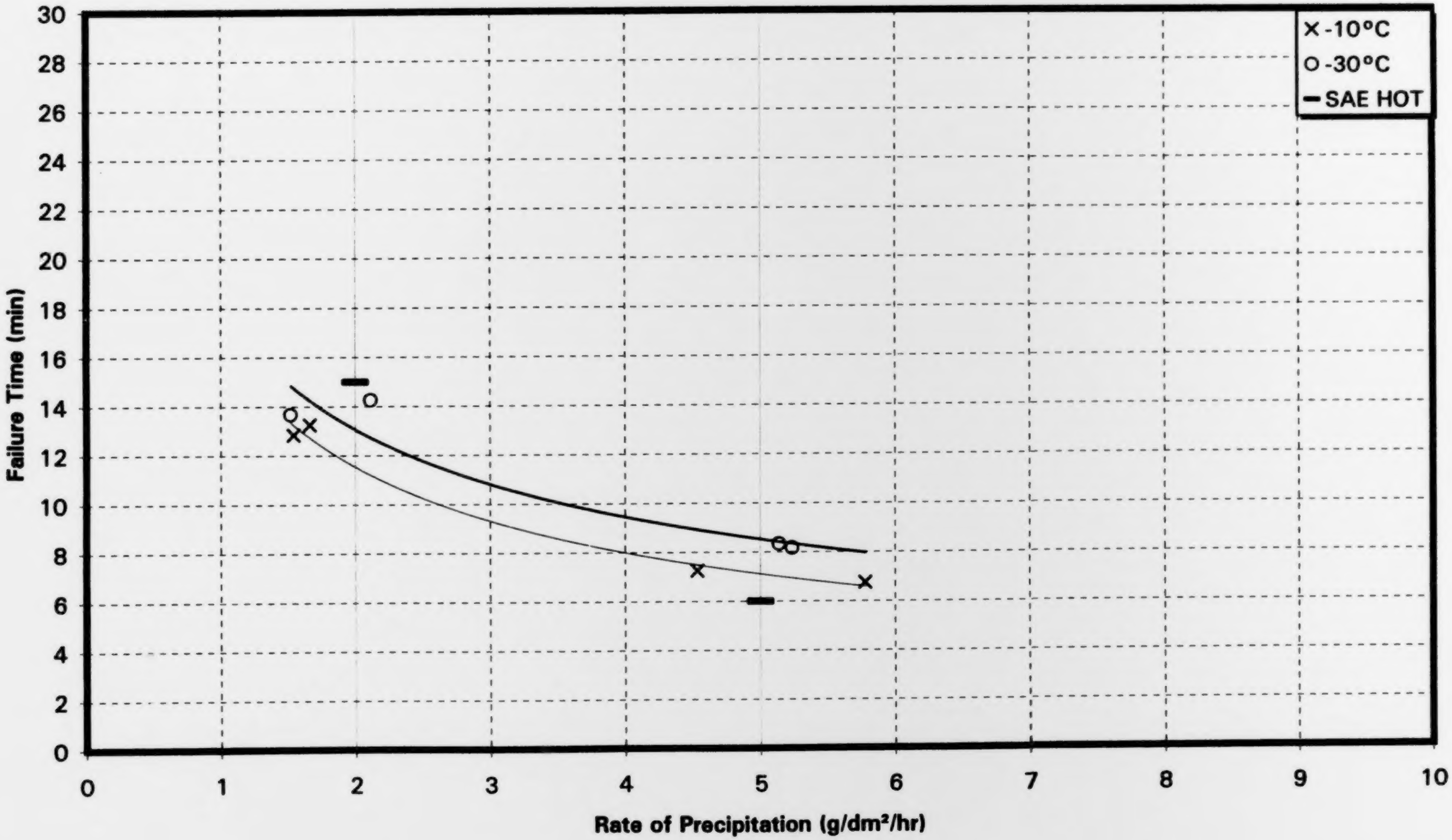


cm1514/analysis/type_1/charts/OCT_EF
At: ZR

EFFECT OF TEMPERATURE AND RATE OF PRECIPITATION ON ENDURANCE TIME

OCTAFLO EF - TYPE I

SIMULATED FREEZING FOG

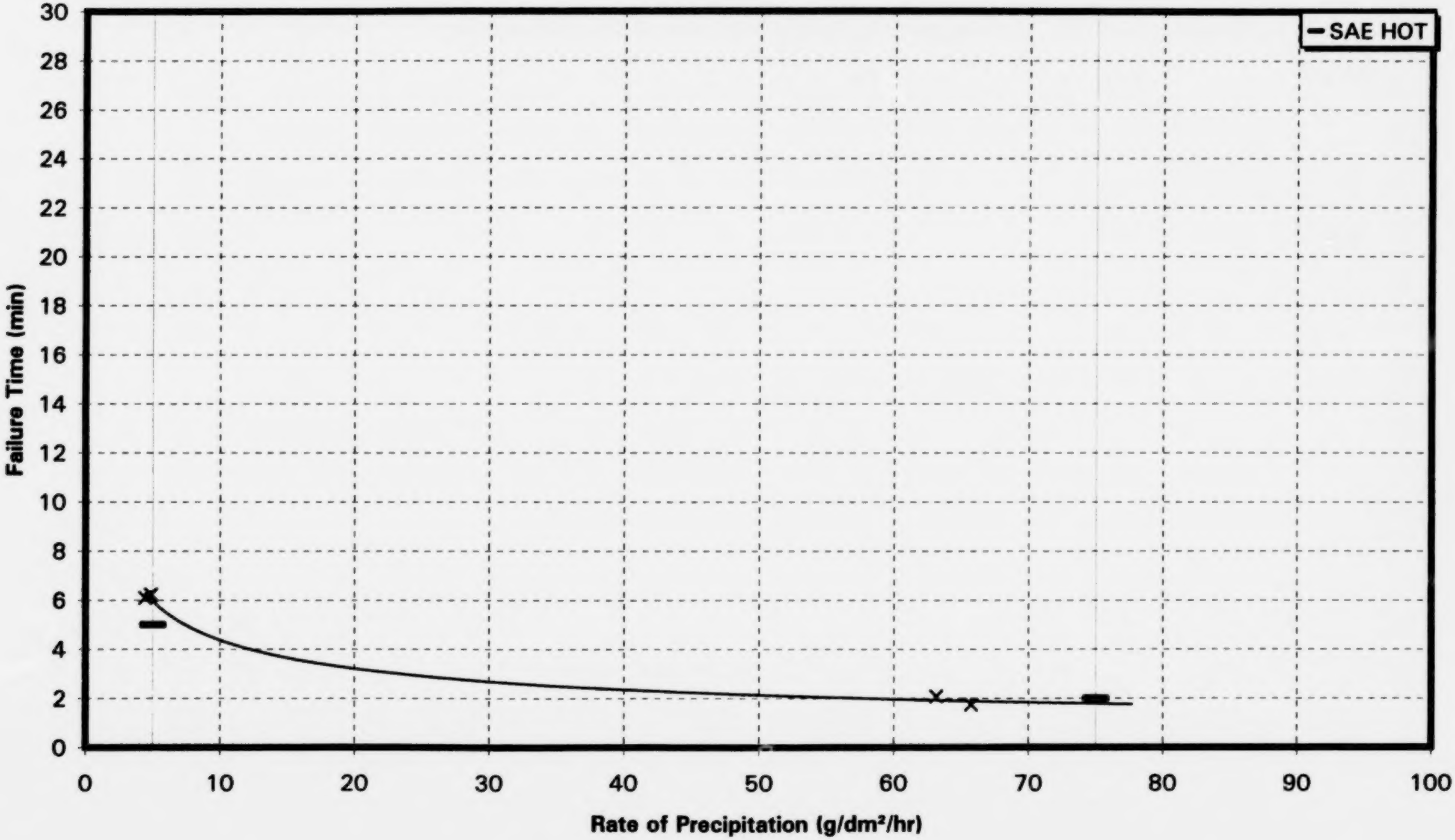


cm1514/analysis/type_1/charts/OCT_EF
At: ZF

EFFECT OF RATE OF PRECIPITATION ON ENDURANCE TIME

OCTAFLO EF - TYPE I

RAIN ON COLD-SOAK SURFACE

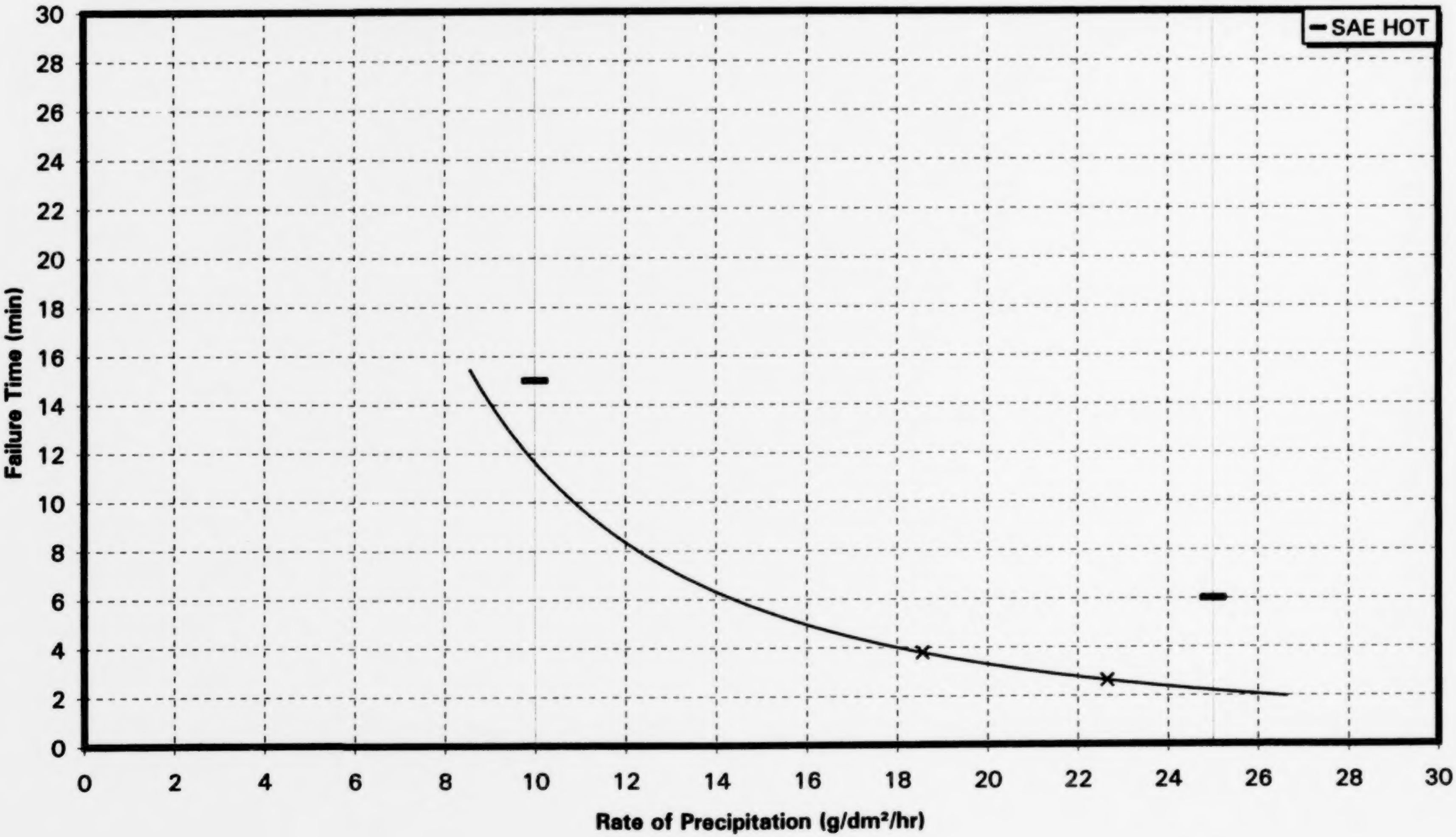


cm1514/analysis/type_1/charts/OCT_EF
At: CS

EFFECT OF RATE OF PRECIPITATION ON ENDURANCE TIME

OCTAFLO EF - TYPE I

SIMULATED SNOW AT -10°C

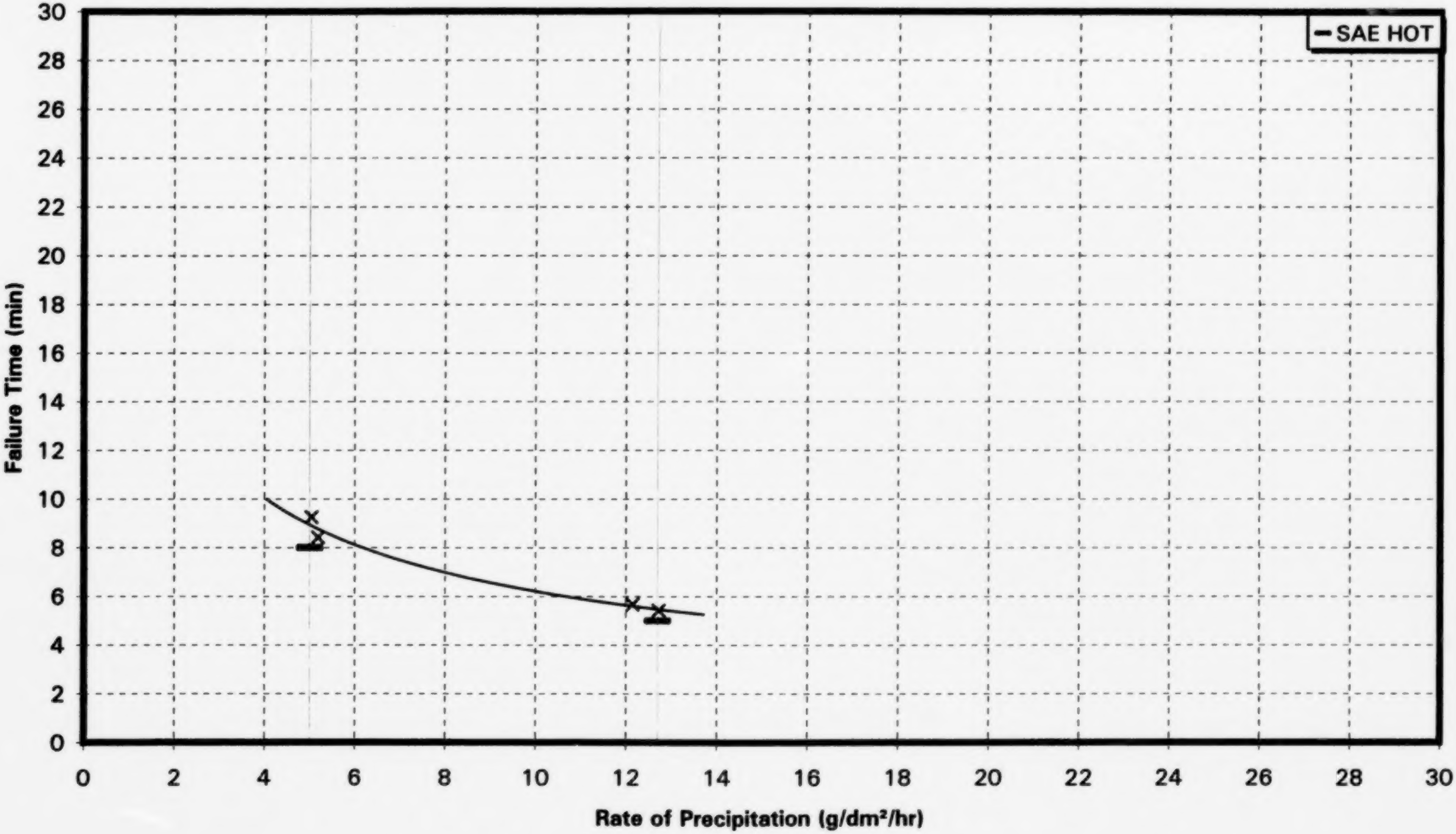


cm1514/analysis/type_1/charts/OCT_EF
At: Snow

EFFECT OF RATE OF PRECIPITATION ON ENDURANCE TIME

KILFROST DF PLUS - TYPE I

SIMULATED FREEZING DRIZZLE AT -10°C

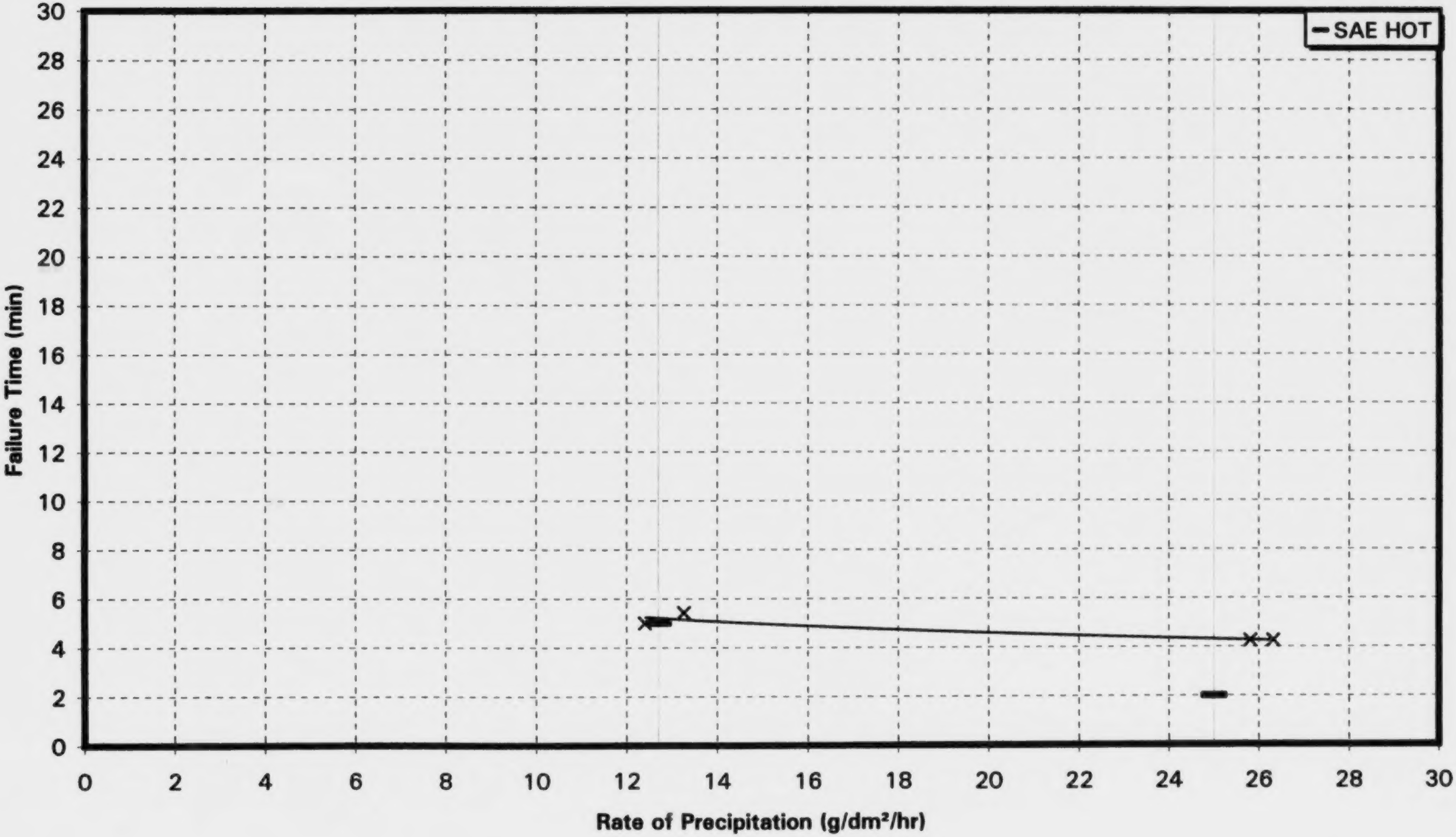


cm1514/analysis/type_1/charts/KILFROST
At: ZD

EFFECT OF RATE OF PRECIPITATION ON ENDURANCE TIME

KILFROST DF PLUS - TYPE I

SIMULATED LIGHT FREEZING RAIN AT -10°C

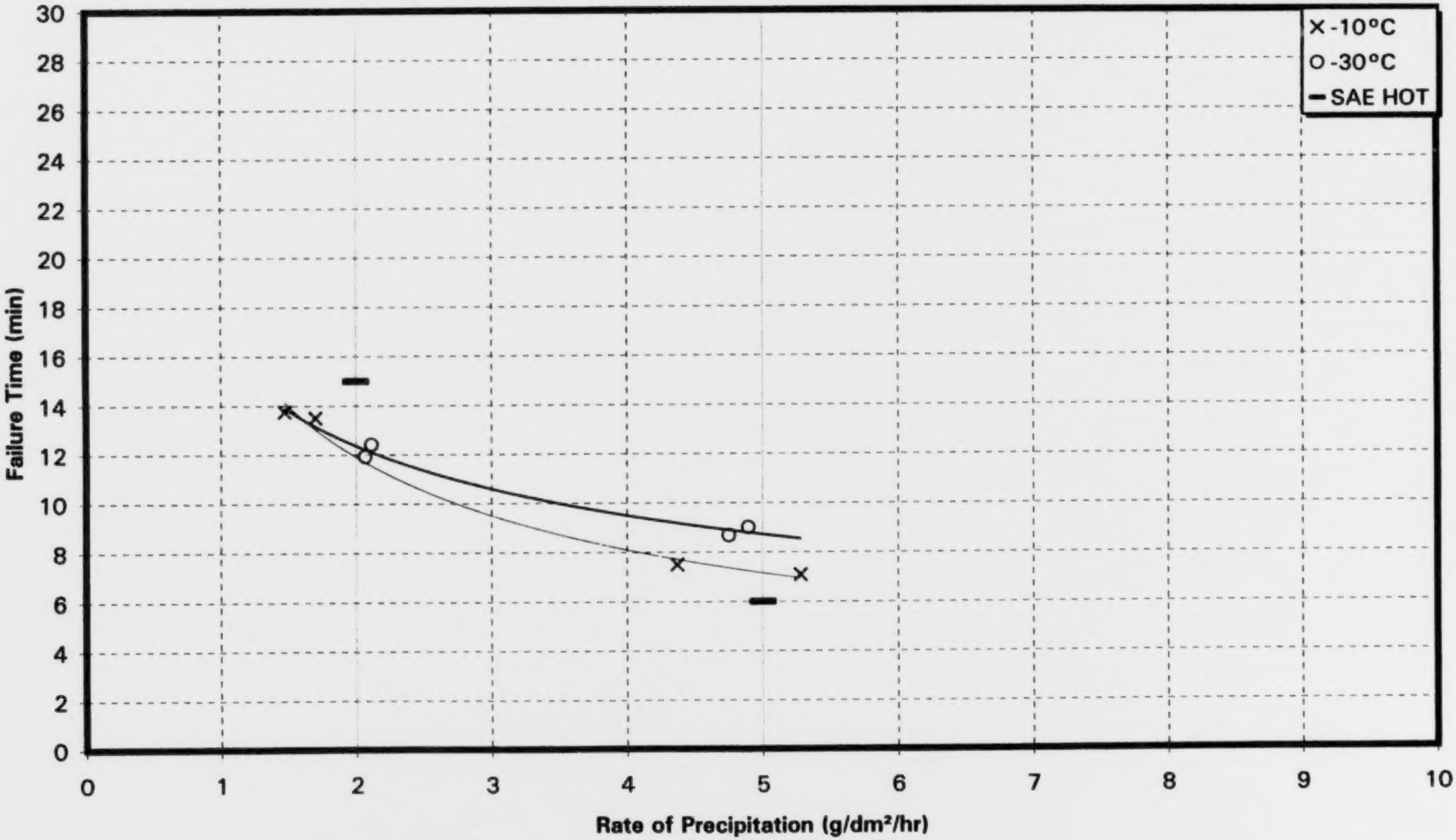


cm1514/analysis/type_1/charts/KILFROST
At: ZR

EFFECT OF TEMPERATURE AND RATE OF PRECIPITATION ON ENDURANCE TIME

KILFROST DF PLUS - TYPE I

SIMULATED FREEZING FOG

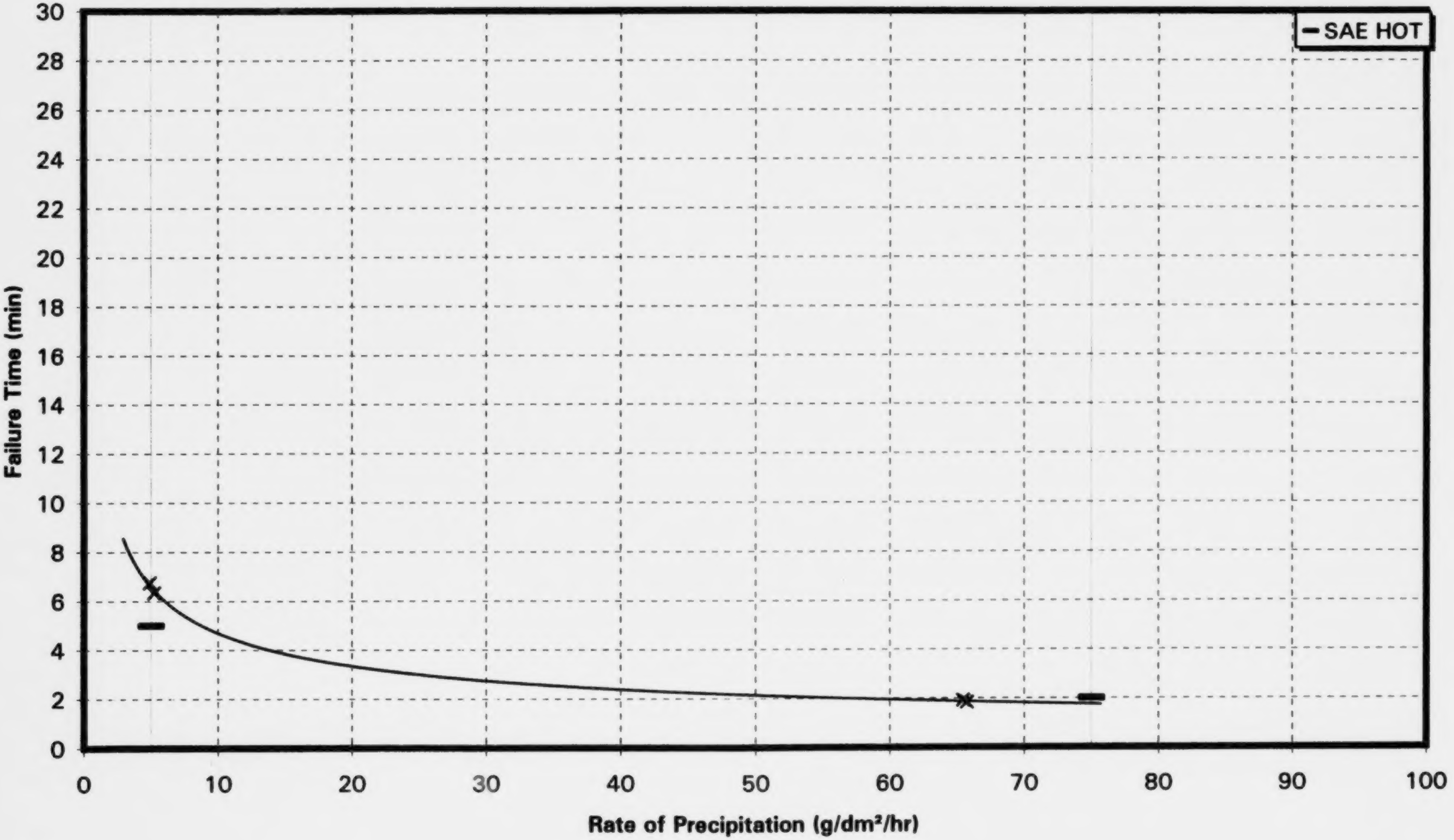


cm1514/analysis/type_1/charts/KILFROST
At: ZF

EFFECT OF RATE OF PRECIPITATION ON ENDURANCE TIME

KILFROST DF PLUS - TYPE I

RAIN ON COLD-SOAK SURFACE

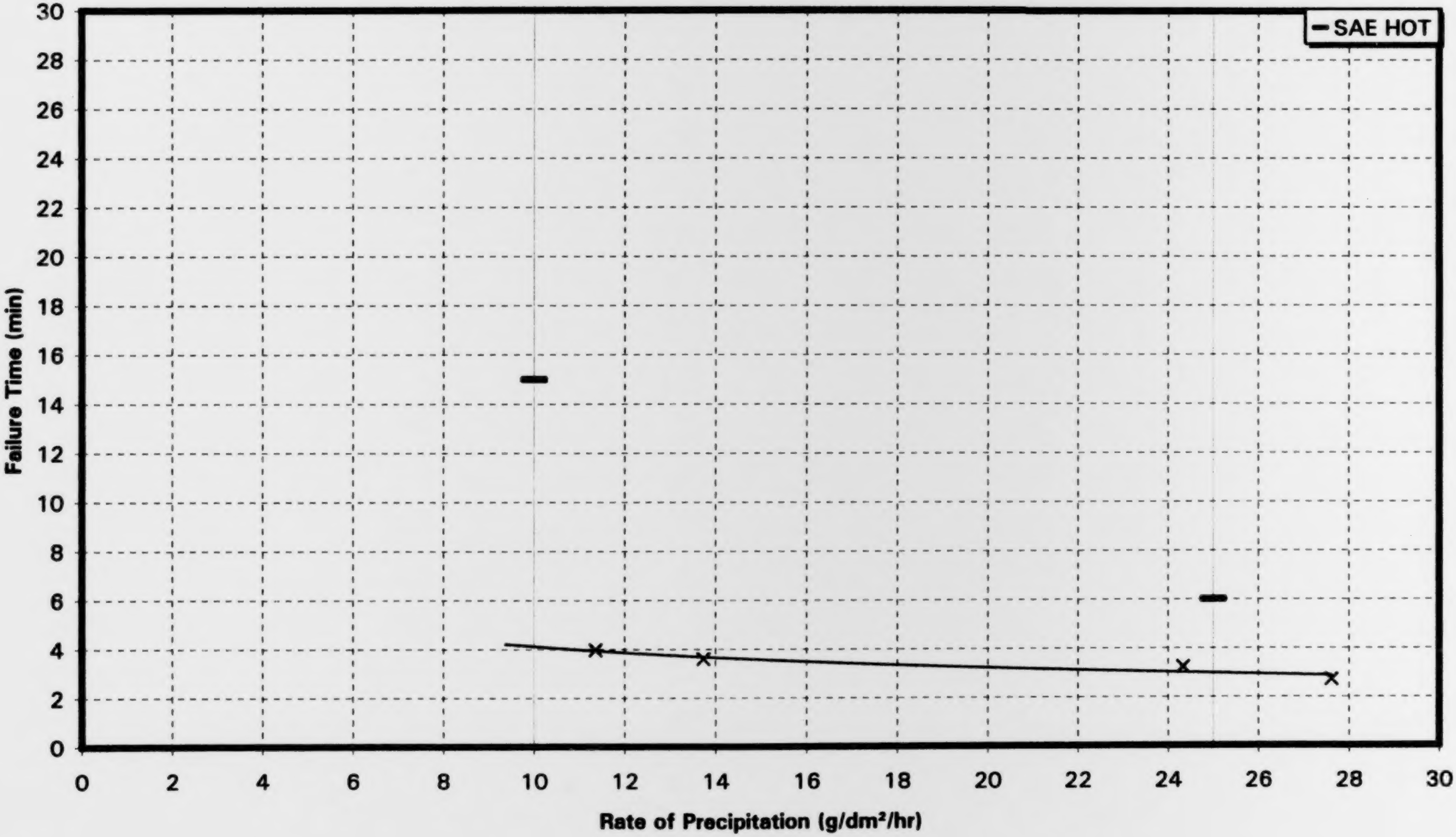


cm1514/analysis/type_1/charts/KILFROST
At: CS

EFFECT OF RATE OF PRECIPITATION ON ENDURANCE TIME

KILFROST DF PLUS - TYPE I

SIMULATED SNOW AT -10°C



cm1514/analysis/type_1/charts/KILFROST
At: Snow

APPENDIX Q

DETAILED RATE DISTRIBUTION MESUREMENTS

ZD @ NRC (-3C)

DETAILED RATE OF PRECIPITATION

Date 30-Mar-99

FORM: 1

PAN #	Plate Loc.	t1 TIME BEFORE	t2 TIME AFTER	w1 WEIGHT BEFORE	w2 WEIGHT AFTER	w2-w1	t2-t1	RATE
3	8-top left	14:08	14:35	81.8	88.8	7	26.6	5.8734
4	8-top right	14:08	14:35	81.8	88.8	7	26.6	5.8734
5	8-bottom left	14:08	14:35	82.4	88	5.6	26.6	4.6987
6	8-bottom right	14:08	14:31	82.8	88.2	5.4	22.6	5.3334

3	4		5	
5.9	5.9		7.9%	7.9%
4.7	5.3		-13.7%	-2.0%
5	6			
		AVG:	5.44	
		STDEV:	0.56	

Needles used:

Flow Rate of Water:

Line Air Pressure:

Line Air Temperature:

Line Water Pressure:

Line Water Temperature:

X Axis	Area	Full	Y
		Partial	
	Speed	High	Y
		Low	
Y Axis	Area	Full	Y
		Partial	
	Speed	High	Y
		Low	

ZD @ NRC (-3C)

DETAILED RATE OF PRECIPITATION

Date 31-Mar-99

FORM: 1

PAN	Plate	t1	t2	w1	w2	w2-w1	t2-t1	RATE
#	Loc.	TIME	TIME	WEIGHT	WEIGHT			
		BEFORE	AFTER	BEFORE	AFTER			
3	2-top left	14:02	14:34	81.6	88.8	7.2	31.9	5.0343
4	2-top right	14:02	14:34	81.6	88.6	7	31.9	4.8945
5	2-bottom left	14:02	14:34	81.8	89.2	7.4	31.9	5.1742
6	2-bottom right	14:02	14:34	81.6	89.2	7.6	31.9	5.314

3	4		5			
5.0	4.9		-1.4%	-4.1%		
5.2	5.3		1.4%	4.1%		
5	6					
		AVG:	5.10			
		STDEV:	0.18			

Needles used:

Flow Rate of Water:

Line Air Pressure:

Line Air Temperature:

Line Water Pressure:

Line Water Temperature:

X Axis	Area	Full	Y
		Partial	
	Speed	High	Y
		Low	
Y Axis	Area	Full	Y
		Partial	
	Speed	High	Y
		Low	

ZR @ NRC (-10C)

DETAILED RATE OF PRECIPITATION

Date 16-Apr-99

FORM: 1

PAN #	Plate Loc.	t1 TIME BEFORE	t2 TIME AFTER	w1 WEIGHT BEFORE	w2 WEIGHT AFTER	w2-w1	t2-t1	RATE
3	1-top left	12:41	13:44	81.8	158.6	76.8	63.1	27.14
4	1-top right	12:41	13:44	81.8	160.8	79	63.1	27.918
5	1-bottom left	12:41	13:44	81.8	147	65.2	63.1	23.041
6	1-bottom right	12:41	13:44	81.8	148.6	66.8	63.1	23.606

		3	4		25.4			
		27.1	27.9		6.7%	9.8%		
		23.0	23.6		-9.4%	-7.2%		
		5	6					
				AVG:	25.43			
				STDEV:	2.46			
Needles used:								
Flow Rate of Water:								
Line Air Pressure:								
Line Air Temperature:								
Line Water Pressure:								
Line Water Temperature:								
X Axis	Area	Full	Y					
		Partial						
	Speed	High	Y					
		Low						
Y Axis	Area	Full	Y					
		Partial						
	Speed	High	Y					
		Low						

freezing drizzle@NRC(-10C)

DETAILED RATE OF PRECIPITATION

Date	28-Apr-99							
FORM:	1							
PAN	**Plate**	**t1**	**t2**	**w1**	**w2**	**w2-w1**	**t2-t1**	**RATE**
#	**Loc.**	**TIME**	**TIME**	**WEIGHT**	**WEIGHT**			
		BEFORE	**AFTER**	**BEFORE**	**AFTER**			
3	4-top left	16:04	16:31	82	96.4	14.4	27.4	11.722
4	4-top right	16:04	16:31	82	96	14	27.4	11.397
5	4-bottom left	16:04	16:31	82	98.4	16.4	27.4	13.35
6	4-bottom right	16:04	16:31	82	98.2	16.2	27.4	13.188
		3	**4**		**12.4**			
		11.7	**11.4**		-5.6%	-8.2%		
		13.4	**13.2**		7.5%	6.2%		
		5	**6**					
				AVG:	**12.41**			
				STDEV:	**1.00**			
Needles used:								
Flow Rate of Water:								
Line Air Pressure:								
Line Air Temperature:								
Line Water Pressure:								
Line Water Temperature:								
X Axis	Area	Full	Y					
		Partial						
	Speed	High	Y					
		Low						
Y Axis	Area	Full	Y					
		Partial						
	Speed	High	Y					
		Low						

RAIN ON COLD-SOAK @ NRC (+1C)
DETAILED RATE OF PRECIPITATION

Date 27-Apr-99
FORM: 1

PAN #	Plate Loc.	t1 TIME BEFORE	t2 TIME AFTER	w1 WEIGHT BEFORE	w2 WEIGHT AFTER	w2-w1	t2-t1	RATE
3	7-top left	12:25	13:24	81.8	274.2	192.4	58.1	73.906
4	7-top right	12:25	13:24	81.8	295	213.2	58.1	81.895
5	7-bottom left	12:25	13:24	81.8	259.6	177.8	58.1	68.297
6	7-bottom right	12:25	13:24	81.8	276.6	194.8	58.1	74.827

3	4		74.7	
73.9	81.9		-1.1%	9.6%
68.3	74.8		-8.6%	0.1%
5	6			
		AVG:	74.73	
		STDEV:	5.58	

Needles used:
Flow Rate of Water:
Line Air Pressure:
Line Air Temperature:
Line Water Pressure:
Line Water Temperature:

X Axis	Area	Full	Y
		Partial	
	Speed	High	Y
		Low	
Y Axis	Area	Full	Y
		Partial	
	Speed	High	Y
		Low	

DRIZZLE COLD-SOAK @ NRC (+1C)
DETAILED RATE OF PRECIPITATION

Date 27-Apr-99

FORM: 1

PAN	Plate	t1	t2	w1	w2	w2-w1	t2-t1	RATE
#	Loc.	TIME	TIME	WEIGHT	WEIGHT			
		BEFORE	AFTER	BEFORE	AFTER			
3	4-top left	10:43	11:44	81.8	274	192.2	61.3	69.916
4	4-top right	10:43	11:44	81.8	280.6	198.8	61.3	72.316
5	4-bottom left	10:43	11:44	81.8	296.4	214.6	61.3	78.064
6	4-bottom right	10:43	11:44	81.6	306.8	225.2	61.3	81.92

3	4		75.6		
69.9	72.3		-7.5%	-4.3%	
78.1	81.9		3.3%	8.4%	
5	6				
		AVG:	75.55		
		STDEV:	5.45		

Needles used:

Flow Rate of Water:

Line Air Pressure:

Line Air Temperature:

Line Water Pressure:

Line Water Temperature:

X Axis	Area	Full	Y
		Partial	
	Speed	High	Y
		Low	
Y Axis	Area	Full	Y
		Partial	
	Speed	High	Y
		Low	

ZF @ NRC (-14C)

DETAILED RATE OF PRECIPITATION

Date	**26-Apr-99**
FORM:	**1**

PAN **#**	**Plate** **Loc.**	**t1** **TIME** **BEFORE**	**t2** **TIME** **AFTER**	**w1** **WEIGHT** **BEFORE**	**w2** **WEIGHT** **AFTER**	**w2-w1**	**t2-t1**	**RATE**
3	7-top left	12:44	13:19	81.6	90.2	8.6	35.2	5.4546
4	7-top right	12:44	13:19	81.6	90.2	8.6	35.2	5.4546
5	7-bottom left	12:44	13:19	81.6	90	8.4	35.2	5.3278
6	7-bottom right	12:44	13:19	81.6	90.2	8.6	35.2	5.4546

3	**4**		**5.4**		
5.5	**5.5**		0.6%	0.6%	
5.3	**5.5**		-1.8%	0.6%	
5	**6**				
		AVG:	**5.42**		
		STDEV:	**0.06**		

Needles used:

Flow Rate of Water:

Line Air Pressure:

Line Air Temperature:

Line Water Pressure:

Line Water Temperature:

X Axis	Area	Full	Y
		Partial	
	Speed	High	Y
		Low	
Y Axis	Area	Full	Y
		Partial	
	Speed	High	Y
		Low	

ZF @ NRC (-14C)

DETAILED RATE OF PRECIPITATION

Date	**22-Apr-99**							
FORM:	**1**							
PAN	**Plate**	**t1**	**t2**	**w1**	**w2**	**w2-w1**	**t2-t1**	**RATE**
#	**Loc.**	**TIME**	**TIME**	**WEIGHT**	**WEIGHT**			
		BEFORE	**AFTER**	**BEFORE**	**AFTER**			
3	2-top left	16:06	16:41	81.6	85.8	4.2	34.4	2.7219
4	2-top right	16:06	16:41	81.6	86	4.4	34.4	2.8516
5	2-bottom left	16:06	16:41	81.6	86.4	4.8	34.4	3.1108
6	2-bottom right	16:06	16:41	81.8	86.2	4.4	34.4	2.8516
		3	**4**		**2.9**			
		2.7	**2.9**		-5.6%	-1.1%		
		3.1	**2.9**		7.9%	-1.1%		
		5	**6**					
				AVG:	**2.88**			
				STDEV:	**0.16**			
Needles used:								
Flow Rate of Water:								
Line Air Pressure:								
Line Air Temperature:								
Line Water Pressure:								
Line Water Temperature:								
X Axis	Area	Full	Y					
		Partial						
	Speed	High	Y					
		Low						
Y Axis	Area	Full	Y					
		Partial						
	Speed	High	Y					
		Low						

RAIN ON COLD-SOAK @ NRC (+1C)
DETAILED RATE OF PRECIPITATION

Date	**16-Apr-99**							
FORM:	**1**							
PAN	**Plate**	**t1**	**t2**	**w1**	**w2**	**w2-w1**	**t2-t1**	**RATE**
#	**Loc.**	**TIME**	**TIME**	**WEIGHT**	**WEIGHT**			
		BEFORE	**AFTER**	**BEFORE**	**AFTER**			
3	12-top left	14:22	14:57	81.8	210.4	128.6	35.3	81.181
4	12-top right	14:22	14:57	81.8	211	129.2	35.3	81.56
5	12-bottom left	14:22	14:57	81.8	202.4	120.6	35.3	76.131
6	12-bottom righ	14:22	14:57	81.6	204.8	123.2	35.3	77.772
		3	**4**		**79.2**			
		81.2	**81.6**		2.6%	3.0%		
		76.1	**77.8**		-3.8%	-1.8%		
		5	**6**					
				AVG:	**79.16**			
				STDEV:	**2.64**			
Needles used:								
Flow Rate of Water:								
Line Air Pressure:								
Line Air Temperature:								
Line Water Pressure:								
Line Water Temperature:								
X Axis	Area	Full	Y					
		Partial						
	Speed	High	Y					
		Low						
Y Axis	Area	Full	Y					
		Partial						
	Speed	High	Y					
		Low						

ZF @ NRC (-3C)

DETAILED RATE OF PRECIPITATION

Date 12-Apr-99

FORM: 1

PAN #	Plate Loc.	t1 TIME BEFORE	t2 TIME AFTER	w1 WEIGHT BEFORE	w2 WEIGHT AFTER	w2-w1	t2-t1	RATE
3	8-top left	13:53	15:10	81.6	88	6.4	76.8	1.9
4	8-top right	13:53	15:10	81.8	88	6.2	76.8	1.8
5	8-bottom left	13:53	15:10	81.6	88.2	6.6	76.8	1.9
6	8-bottom right	13:53	15:10	81.6	88	6.4	76.8	1.9

3	4	1.9	
1.9	1.8	0.0%	-3.1%
1.9	1.9	3.1%	0.0%
5	6		

AVG: 1.86

STDEV: 0.05

Needles used:

Flow Rate of Water:

Line Air Pressure:

Line Air Temperature:

Line Water Pressure:

Line Water Temperature:

X Axis	Area	Full	Y
		Partial	
	Speed	High	Y
		Low	
Y Axis	Area	Full	Y
		Partial	
	Speed	High	Y
		Low	

ZR @ NRC (-10C)

DETAILED RATE OF PRECIPITATION

Date 16-Apr-99

FORM: 1

PAN	Plate	t1	t2	w1	w2	w2-w1	t2-t1	RATE
#	Loc.	TIME	TIME	WEIGHT	WEIGHT			
		BEFORE	AFTER	BEFORE	AFTER			
3	4-top left	14:00	15:03	82	160	78	62.8	27.711
4	4-top right	14:00	15:03	81.8	156.4	74.6	62.8	26.503
5	4-bottom left	14:00	15:03	81.8	150.2	68.4	62.8	24.3
6	4-bottom right	14:00	15:03	81.6	146.4	64.8	62.8	23.021

3	4		25.4			
27.7	26.5		9.2%	4.4%		
24.3	23.0		-4.3%	-9.3%		
5	6					
		AVG:	25.38			
		STDEV:	2.12			

Needles used:

Flow Rate of Water:

Line Air Pressure:

Line Air Temperature:

Line Water Pressure:

Line Water Temperature:

X Axis	Area	Full	Y
		Partial	
	Speed	High	Y
		Low	
Y Axis	Area	Full	Y
		Partial	
	Speed	High	Y
		Low	

ZD @ NRC (-3C)

DETAILED RATE OF PRECIPITATION

Date 7-Apr-99

FORM: 1

PAN	Plate	t1	t2	w1	w2	w2-w1	t2-t1	RATE
#	Loc.	TIME	TIME	WEIGHT	WEIGHT			
		BEFORE	AFTER	BEFORE	AFTER			
3	5-top left	12:12	12:43	81.8	98.8	17	30.8	12.331
4	5-top right	12:12	12:43	81.6	98.8	17.2	30.8	12.476
5	5-bottom left	12:12	12:43	81.6	100.2	18.6	30.8	13.492
6	5-bottom right	12:12	12:43	81.6	100.2	18.6	30.8	13.492

		3	4		12.9			
		12.3	12.5		-4.8%	-3.6%		
		13.5	13.5		4.2%	4.2%		
		5	6					
				AVG:	12.95			
				STDEV:	0.63			

Needles used:

Flow Rate of Water:

Line Air Pressure:

Line Air Temperature:

Line Water Pressure:

Line Water Temperature:

X Axis	Area	Full	Y
		Partial	
	Speed	High	Y
		Low	
Y Axis	Area	Full	Y
		Partial	
	Speed	High	Y
		Low	

ZR @ NRC (-3C)

DETAILED RATE OF PRECIPITATION

Date 7-Apr-99

FORM: 1

PAN #	Plate Loc.	t1 TIME BEFORE	t2 TIME AFTER	w1 WEIGHT BEFORE	w2 WEIGHT AFTER	w2-w1	t2-t1	RATE
3	8-top left	10:16	10:49	81.6	98.8	17.2	32.8	11.685
4	8-top right	10:16	10:49	81.6	98.4	16.8	32.8	11.413
5	8-bottom left	10:16	10:49	81.6	101.4	19.8	32.8	13.451
6	8-bottom right	10:16	10:49	81.6	101.4	19.8	32.8	13.451

3	4		12.5			
11.7	11.4		-6.5%	-8.7%		
13.5	13.5		7.6%	7.6%		
5	6					
		AVG:	12.50			
		STDEV:	1.10			

Needles used:

Flow Rate of Water:

Line Air Pressure:

Line Air Temperature:

Line Water Pressure:

Line Water Temperature:

X Axis	Area	Full	Y
		Partial	
	Speed	High	Y
		Low	
Y Axis	Area	Full	Y
		Partial	
	Speed	High	Y
		Low	

ZR @ NRC (-3C)

DETAILED RATE OF PRECIPITATION

Date 6-Apr-99

FORM: 1

PAN #	Plate Loc.	t1 TIME BEFORE	t2 TIME AFTER	w1 WEIGHT BEFORE	w2 WEIGHT AFTER	w2-w1	t2-t1	RATE
3	7-top left	15:17	15:49	81.8	118	36.2	32.4	24.895
4	7-top right	15:17	15:49	81.8	117.8	36	32.4	24.758
5	7-bottom left	15:17	15:49	81.8	117	35.2	32.4	24.208
6	7-bottom right	15:17	15:49	81.8	117.8	36	32.4	24.758

3	4		24.7	
24.9	24.8		1.0%	0.4%
24.2	24.8		-1.8%	0.4%
5	6			
		AVG:	24.65	
		STDEV:	0.30	

Needles used:

Flow Rate of Water:

Line Air Pressure:

Line Air Temperature:

Line Water Pressure:

Line Water Temperature:

X Axis	Area	Full	Y
		Partial	
	Speed	High	Y
		Low	
Y Axis	Area	Full	Y
		Partial	
	Speed	High	Y
		Low	

ZR @ NRC (-3C)

DETAILED RATE OF PRECIPITATION

Date 6-Apr-99

FORM: 1

PAN	Plate	t1	t2	w1	w2	w2-w1	t2-t1	RATE
#	Loc.	TIME	TIME	WEIGHT	WEIGHT			
		BEFORE	AFTER	BEFORE	AFTER			
3	1-top left	14:04	14:37	81.8	120.8	39	33.8	25.736
4	1-top right	14:04	14:37	81.6	120.8	39.2	33.8	25.868
5	1-bottom left	14:04	14:37	81.6	121	39.4	33.8	26
6	1-bottom right	14:04	14:37	81.6	121	39.4	33.8	26

3	4		26	
25.7	25.9		-0.6%	-0.1%
26.0	26.0		0.4%	0.4%
5	6			
		AVG:	25.90	
		STDEV:	0.13	

Needles used:

Flow Rate of Water:

Line Air Pressure:

Line Air Temperature:

Line Water Pressure:

Line Water Temperature:

X Axis	Area	Full	Y
		Partial	
	Speed	High	Y
		Low	
Y Axis	Area	Full	Y
		Partial	
	Speed	High	Y
		Low	

ZR @ NRC (-3C)

DETAILED RATE OF PRECIPITATION

Date	**6-Apr-99**
FORM:	**1**

PAN	Plate	t1	t2	w1	w2	w2-w1	t2-t1	RATE
#	Loc.	TIME	TIME	WEIGHT	WEIGHT			
		BEFORE	AFTER	BEFORE	AFTER			
3	1-top left	14:45	15:03	82.2	102.4	20.2	17.5	25.82
4	1-top right	14:45	15:03	82.6	103.6	21	17.5	26.842
5	1-bottom left	14:45	15:03	82.2	102	19.8	17.5	25.309
6	1-bottom right	14:45	15:03	82	102.8	20.8	17.5	26.587

3	**4**		**26.1**		
25.8	**26.8**		-1%	3%	
25.3	**26.6**		-3%	2%	
5	**6**				
		AVG:	**26.14**		
		STDEV:	**0.70**		

Needles used:

Flow Rate of Water:

Line Air Pressure:

Line Air Temperature:

Line Water Pressure:

Line Water Temperature:

X Axis	Area	Full	Y
		Partial	
	Speed	High	Y
		Low	
Y Axis	Area	Full	Y
		Partial	
	Speed	High	Y
		Low	

ZR- @ NRC (-3C)

DETAILED RATE OF PRECIPITATION

Date 1-Apr-99

FORM: 1

PAN #	Plate Loc.	t1 TIME BEFORE	t2 TIME AFTER	w1 WEIGHT BEFORE	w2 WEIGHT AFTER	w2-w1	t2-t1	RATE
3	11-top left	15:07	15:22	81.6	99.2	17.6	14.9	26.347
4	11-top right	15:07	15:22	81.8	99.2	17.4	14.9	26.047
5	11-bottom left	15:07	15:22	81.6	98.4	16.8	14.9	25.149
6	11-bottom righ	15:07	15:22	81.6	98.6	17	14.9	25.448

3	4		26			
26.3	26.0		2.3%	1.2%		
25.1	25.4		-2.3%	-1.2%		
5	6					
		AVG:	25.75			
		STDEV:	0.55			

Needles used:

Flow Rate of Water:

Line Air Pressure:

Line Air Temperature:

Line Water Pressure:

Line Water Temperature:

X Axis	Area	Full	Y
		Partial	
	Speed	High	Y
		Low	
Y Axis	Area	Full	Y
		Partial	
	Speed	High	Y
		Low	

ZD @ NRC (-3C)

DETAILED RATE OF PRECIPITATION

Date 30-Mar-99

FORM: 1

PAN #	Plate Loc.	t1 TIME BEFORE	t2 TIME AFTER	w1 WEIGHT BEFORE	w2 WEIGHT AFTER	w2-w1	t2-t1	RATE
3	1-top left	17:31	18:03	81.8	89.6	7.8	31.9	5.4596
4	1-top right	17:31	18:03	81.8	89	7.2	31.9	5.0396
5	1-bottom left	17:31	18:03	81.6	90.8	9.2	31.9	6.4395
6	1-bottom right	17:31	18:03	82	90.4	8.4	31.9	5.8795

3	4		6	
5.5	5.0		-4.3%	-11.7%
6.4	5.9		12.9%	3.1%
5	6			
		AVG:	5.70	
		STDEV:	0.60	

Needles used:

Flow Rate of Water:

Line Air Pressure:

Line Air Temperature:

Line Water Pressure:

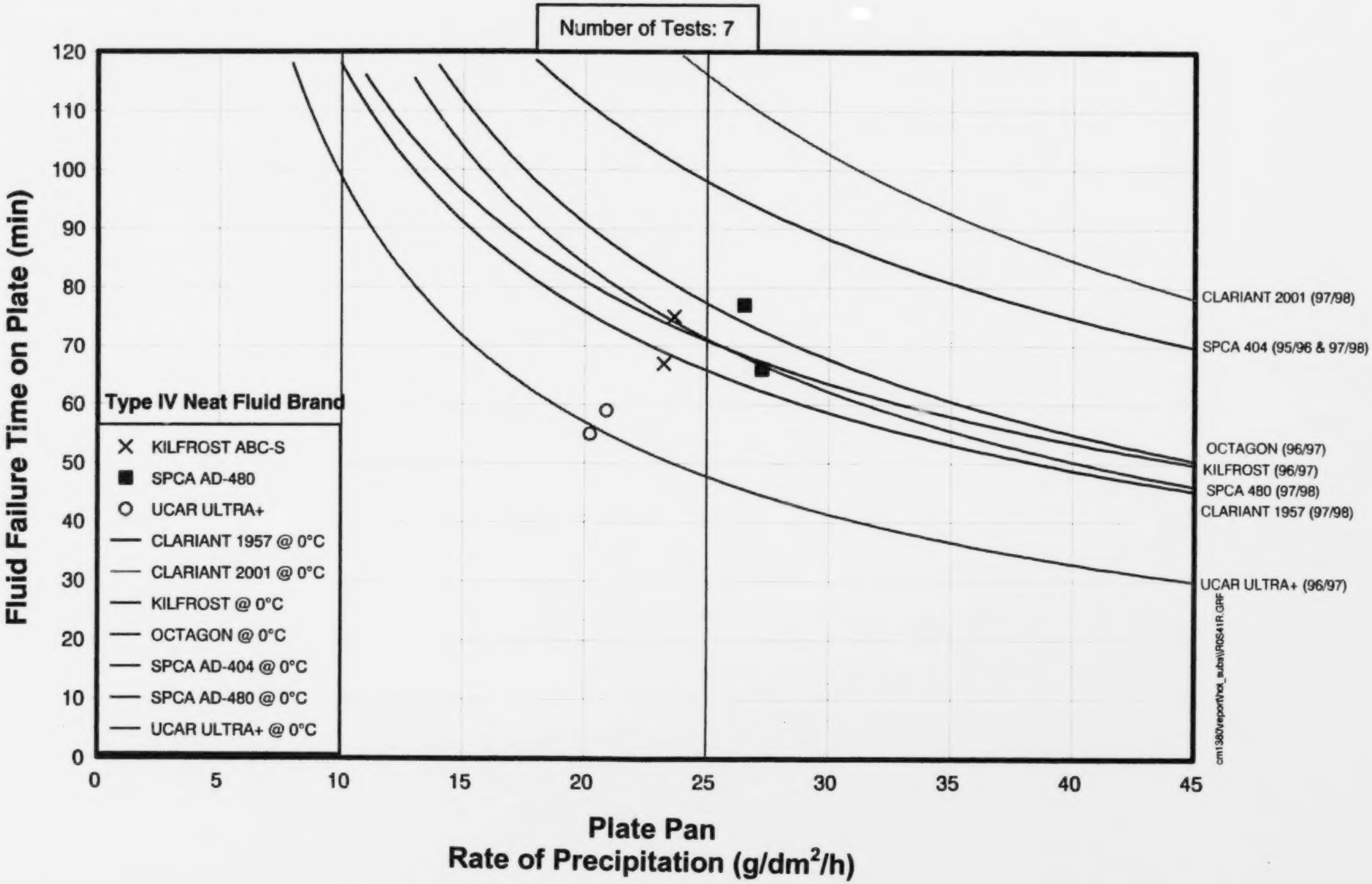
Line Water Temperature:

X Axis	Area	Full	Y
		Partial	
	Speed	High	Y
		Low	
Y Axis	Area	Full	Y
		Partial	
	Speed	High	Y
		Low	

APPENDIX R

1996-97 AND 1997-98
HOLDOVER TIME RESULTS

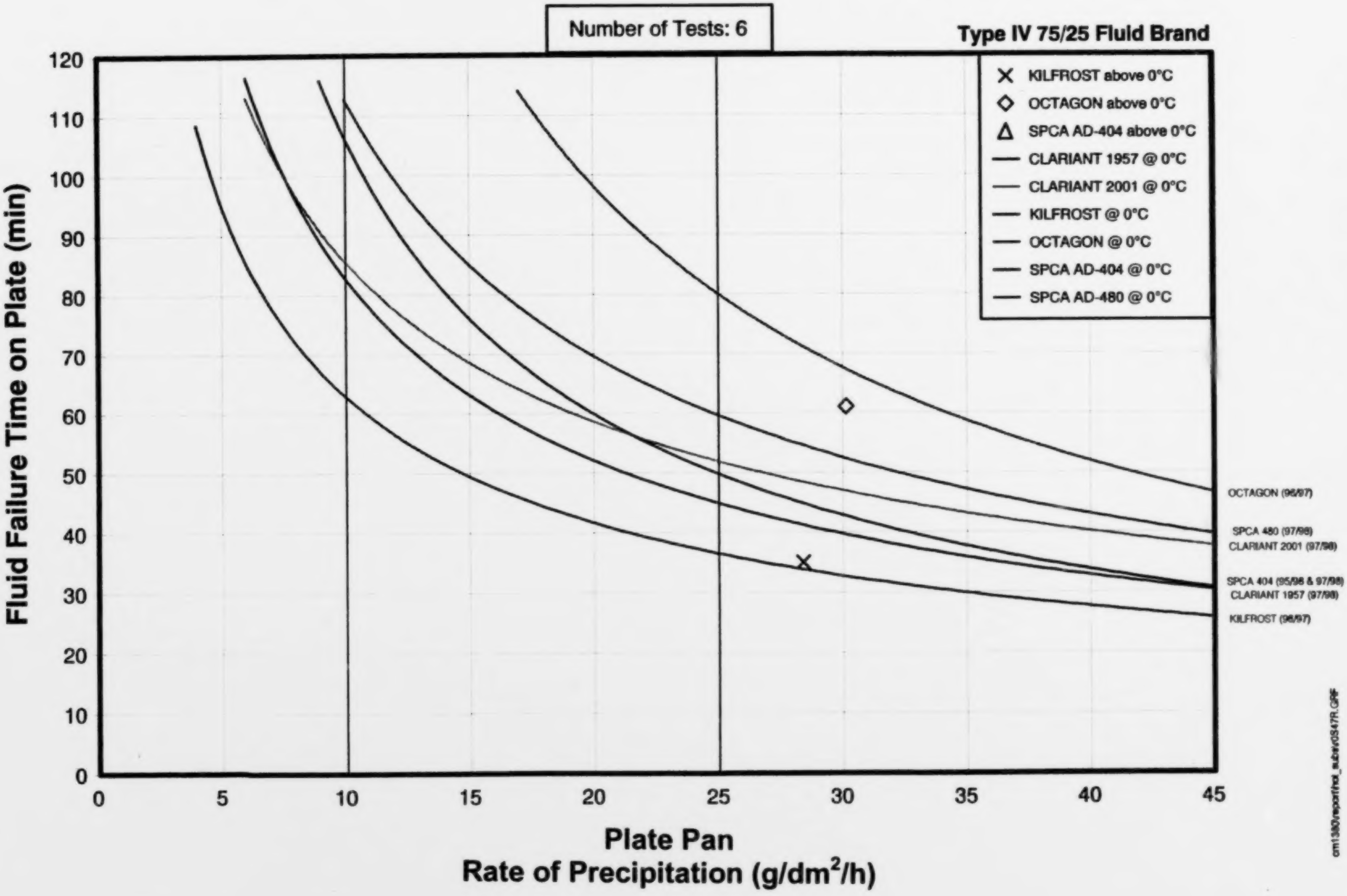
EFFECT OF FLUID BRAND AND RATE OF PRECIPITATION ON FAILURE TIME
TYPE IV NEAT (above 0°C)
NATURAL SNOW CONDITIONS



EFFECT OF FLUID BRAND AND RATE OF PRECIPITATION ON FAILURE TIME

TYPE IV 75/25 (Above 0°C)

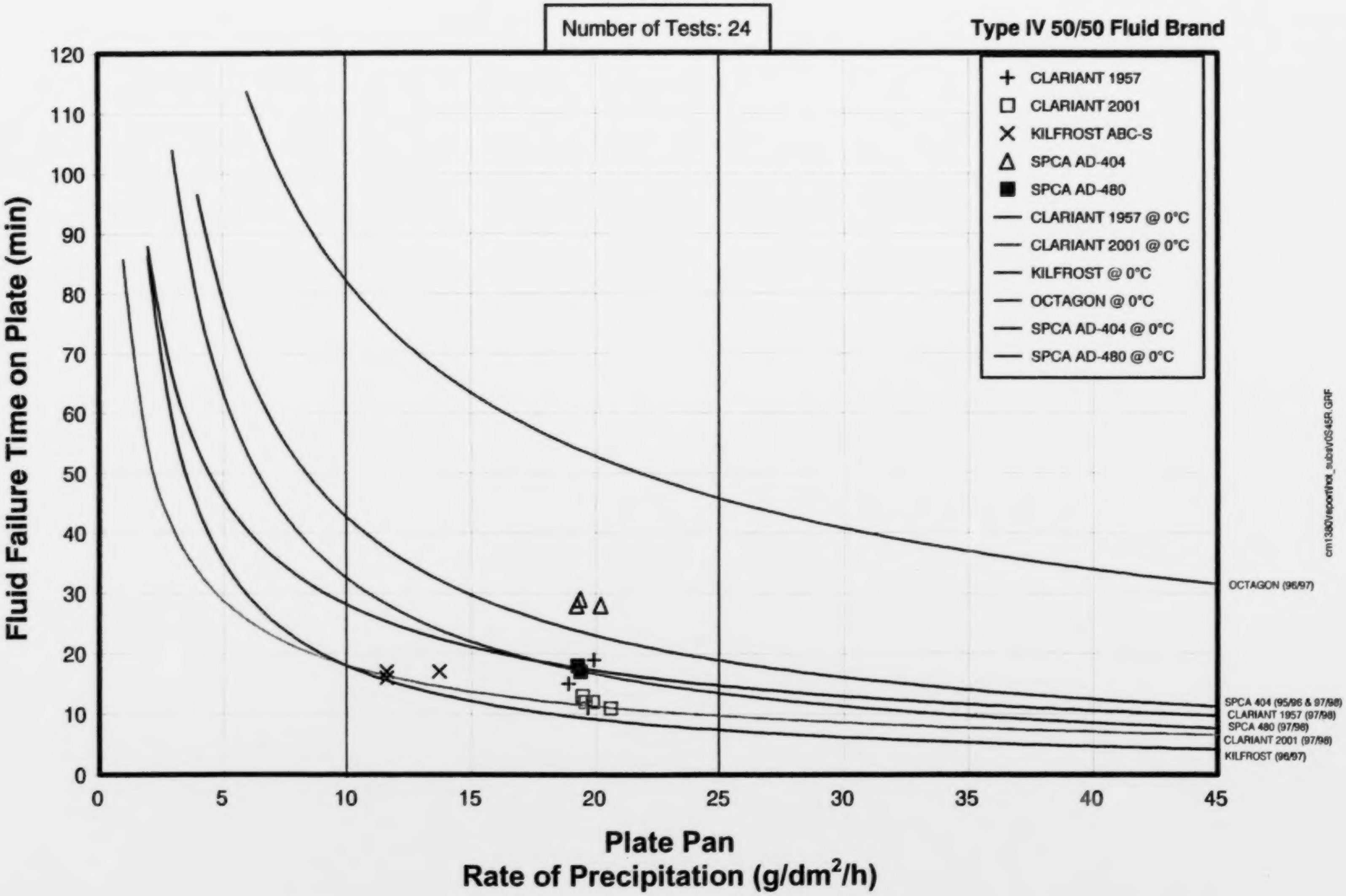
NATURAL SNOW CONDITIONS



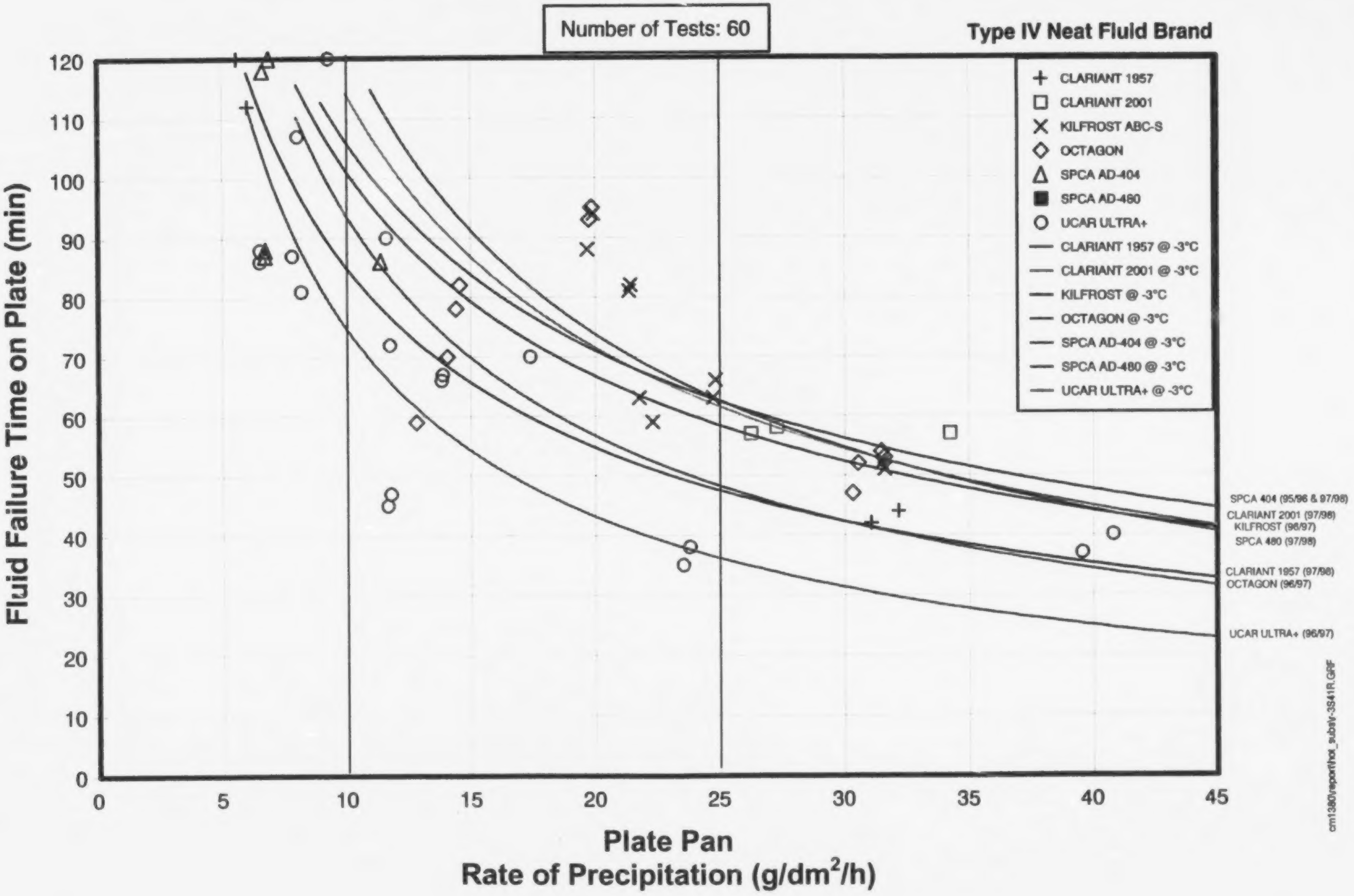
EFFECT OF FLUID BRAND AND RATE OF PRECIPITATION ON FAILURE TIME

TYPE IV 50/50 (Above 0°C)

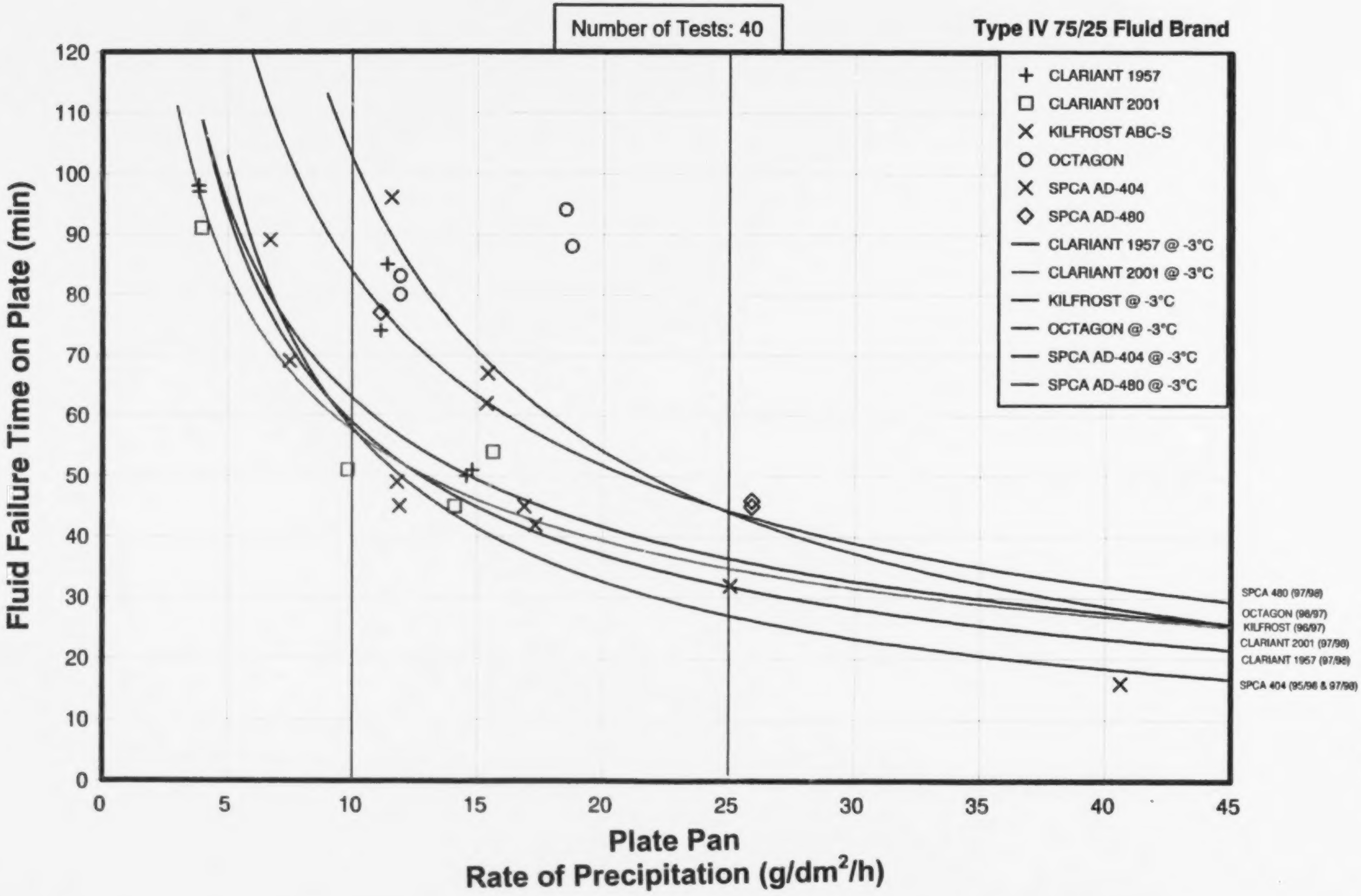
NATURAL SNOW CONDITIONS



EFFECT OF FLUID BRAND AND RATE OF PRECIPITATION ON FAILURE TIME
TYPE IV NEAT (0 to -3°C)
NATURAL SNOW CONDITIONS



EFFECT OF FLUID BRAND AND RATE OF PRECIPITATION ON FAILURE TIME
TYPE IV 75/25 (0 to -3°C)
NATURAL SNOW CONDITIONS

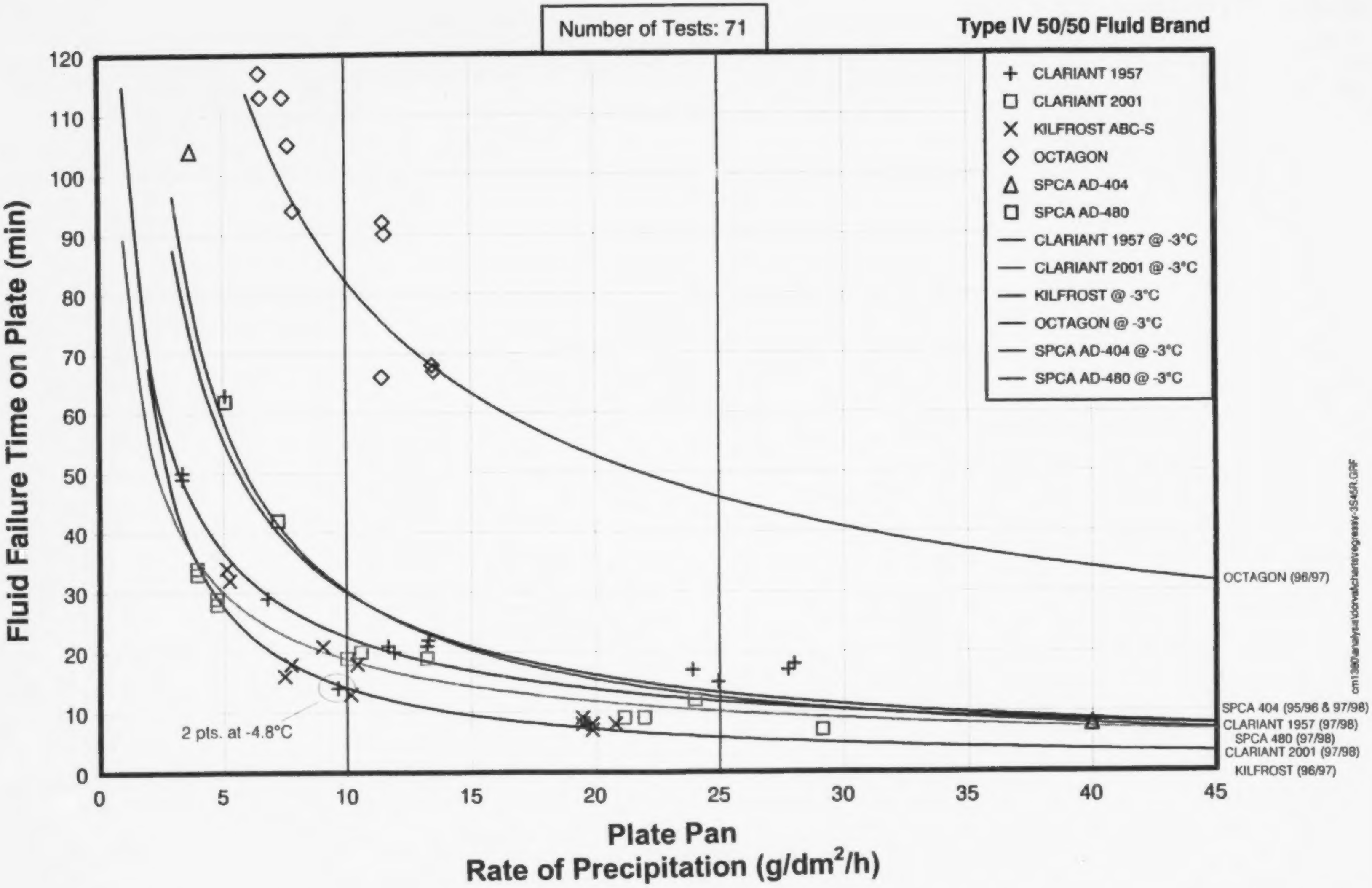


cm1380/report/nat_subs/IV-3S47R.GRF

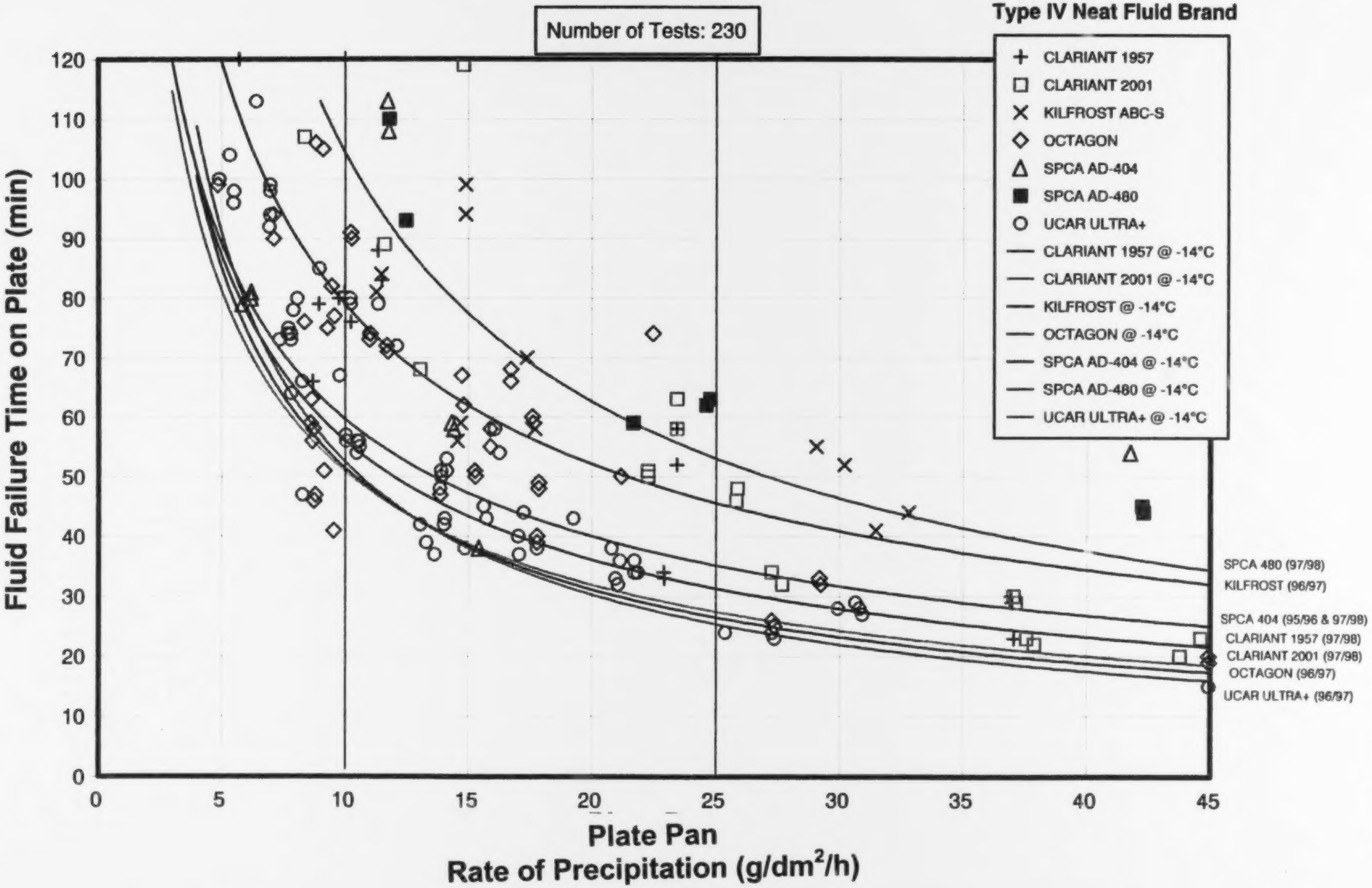
EFFECT OF FLUID BRAND AND RATE OF PRECIPITATION ON FAILURE TIME

TYPE IV 50/50 (0 to -3°C)

NATURAL SNOW CONDITIONS



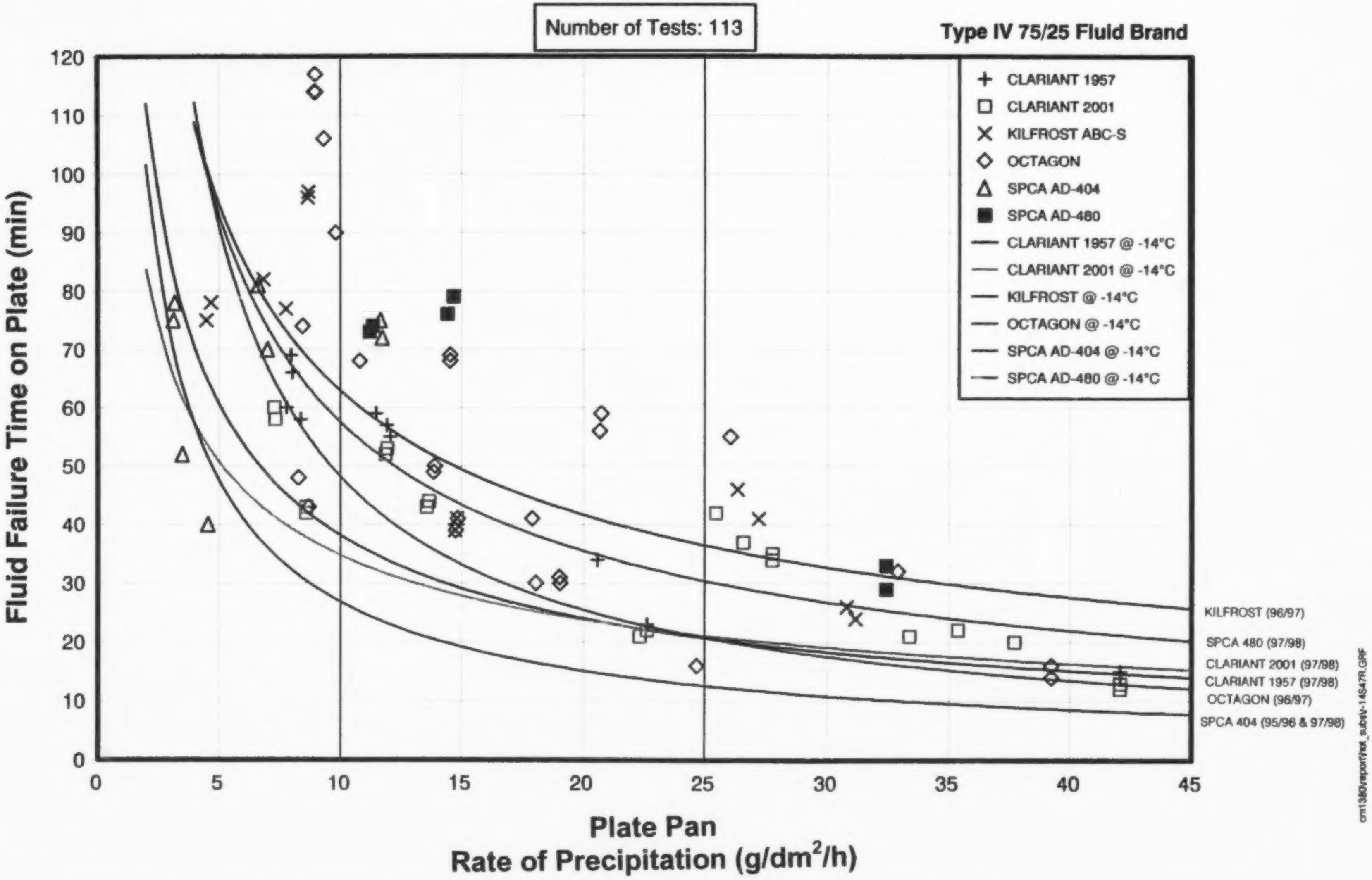
EFFECT OF FLUID BRAND AND RATE OF PRECIPITATION ON FAILURE TIME
TYPE IV NEAT (-3 to -14°C)
NATURAL SNOW CONDITIONS



EFFECT OF FLUID BRAND AND RATE OF PRECIPITATION ON FAILURE TIME

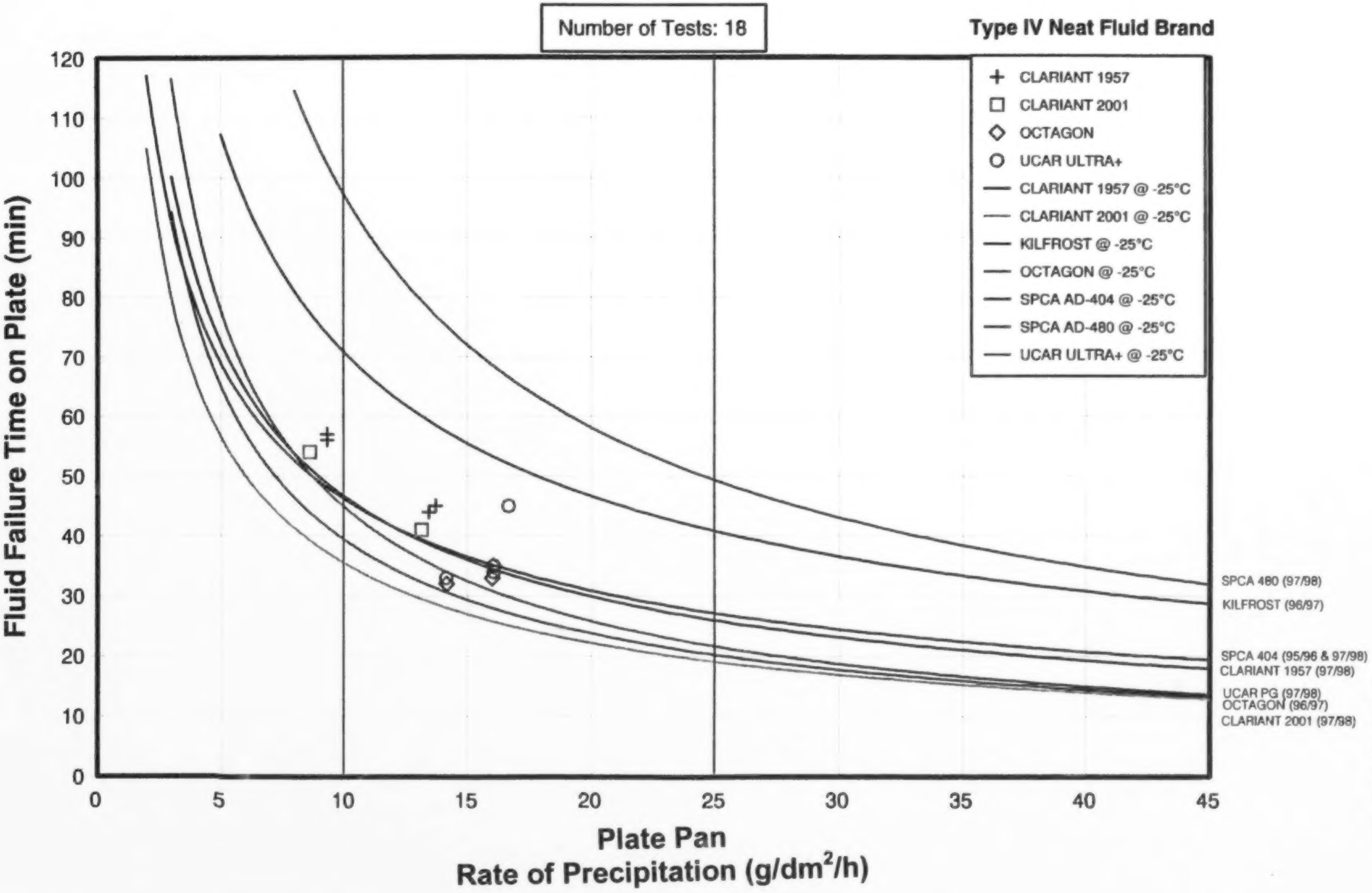
TYPE IV 75/25 (-3 to -14°C)

NATURAL SNOW CONDITIONS



EFFECT OF FLUID BRAND AND RATE OF PRECIPITATION ON FAILURE TIME

TYPE IV NEAT (-14 to -25°C)
NATURAL SNOW CONDITIONS

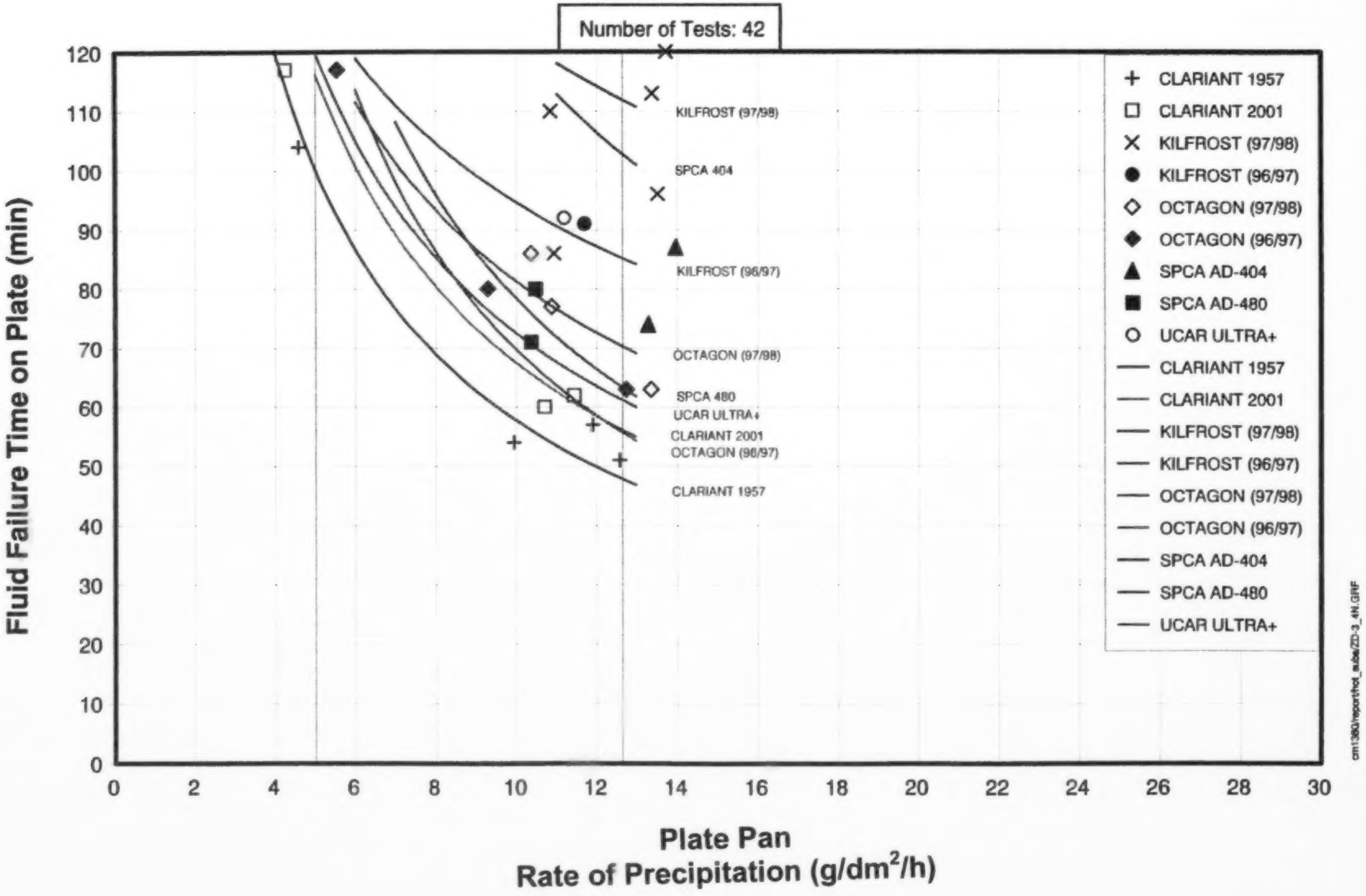


cm1380\report\not_subs\V-25S41R.GRF

EFFECT OF FLUID BRAND AND RATE OF PRECIPITATION ON FAILURE TIME

TYPE IV NEAT

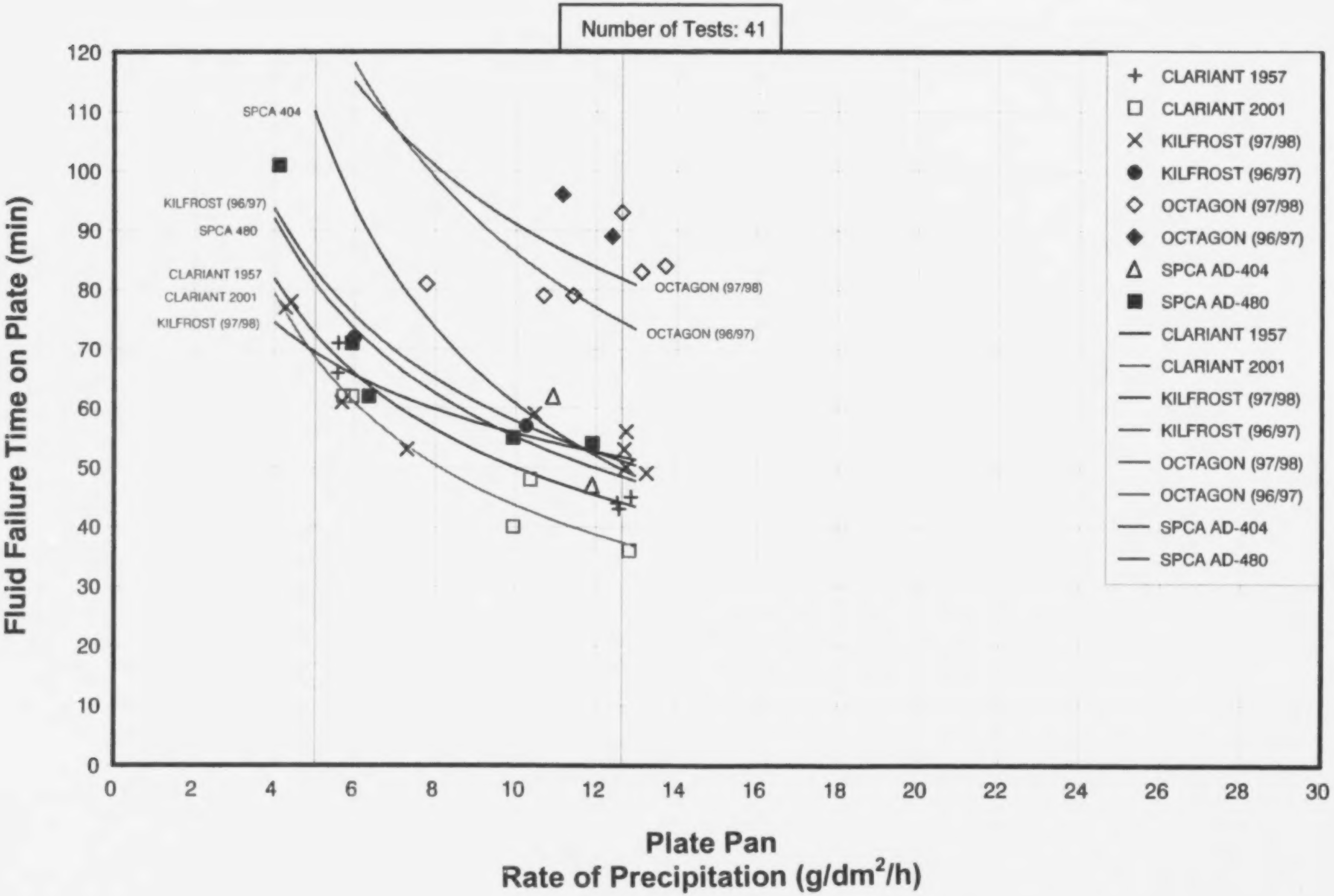
FREEZING DRIZZLE AT -3°C



EFFECT OF FLUID BRAND AND RATE OF PRECIPITATION ON FAILURE TIME

TYPE IV 75/25

FREEZING DRIZZLE AT -3°C

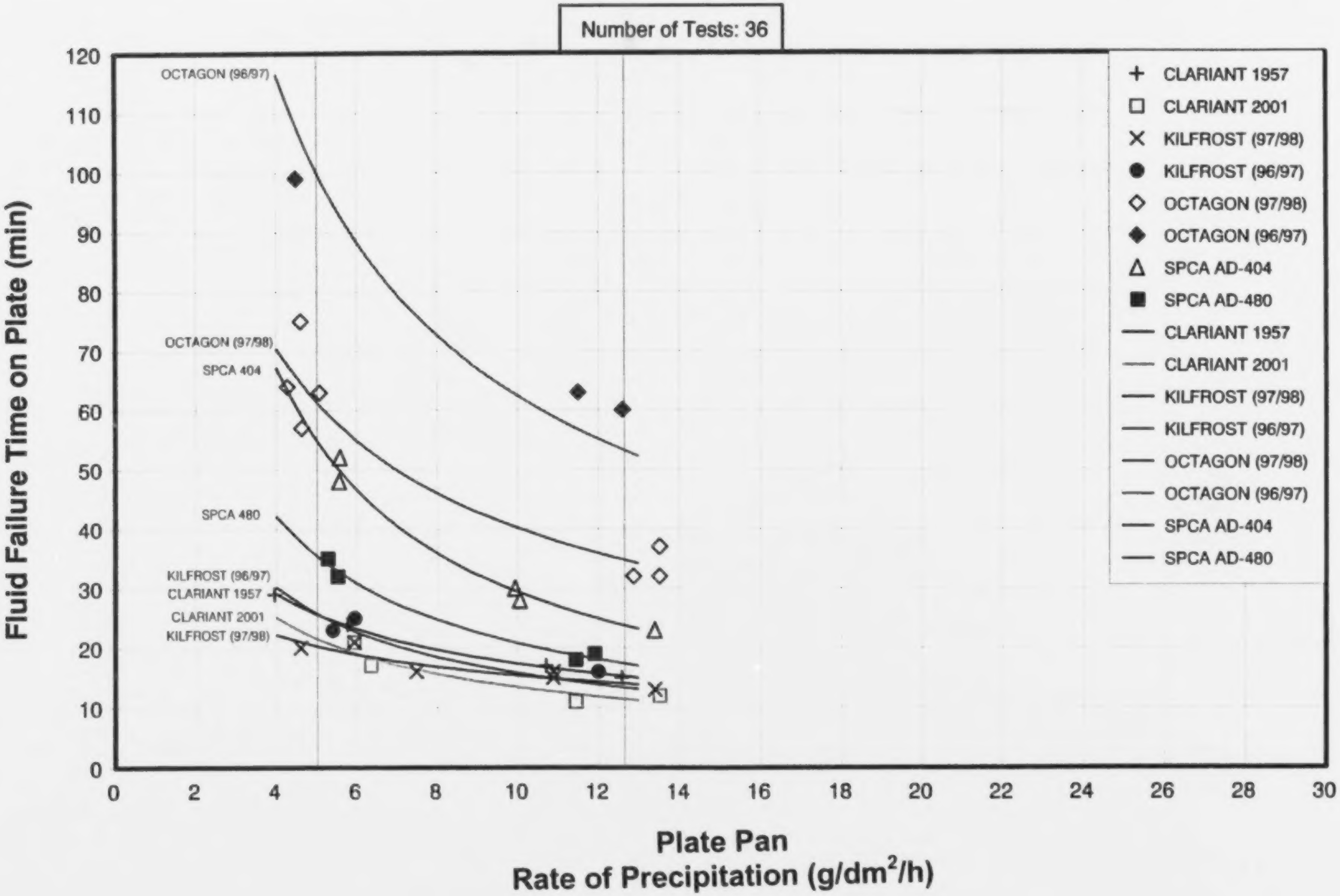


cm1380/reports/hot_subs/ZD-3_48.GRF

EFFECT OF FLUID BRAND AND RATE OF PRECIPITATION ON FAILURE TIME

TYPE IV 50/50

FREEZING DRIZZLE AT -3°C

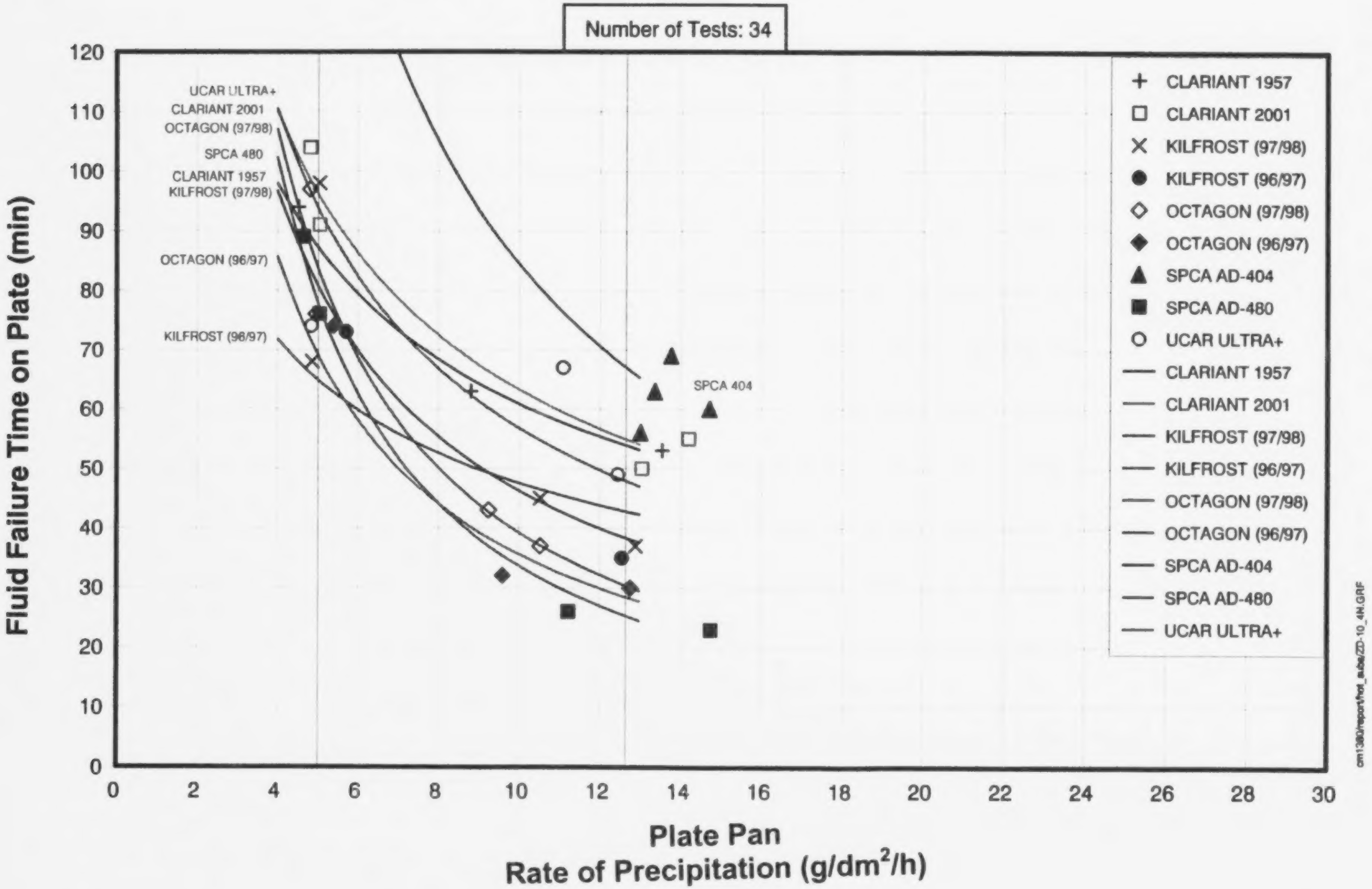


cm1360/report/hot_subs/ZD-3_4A.GRF

EFFECT OF FLUID BRAND AND RATE OF PRECIPITATION ON FAILURE TIME

TYPE IV NEAT

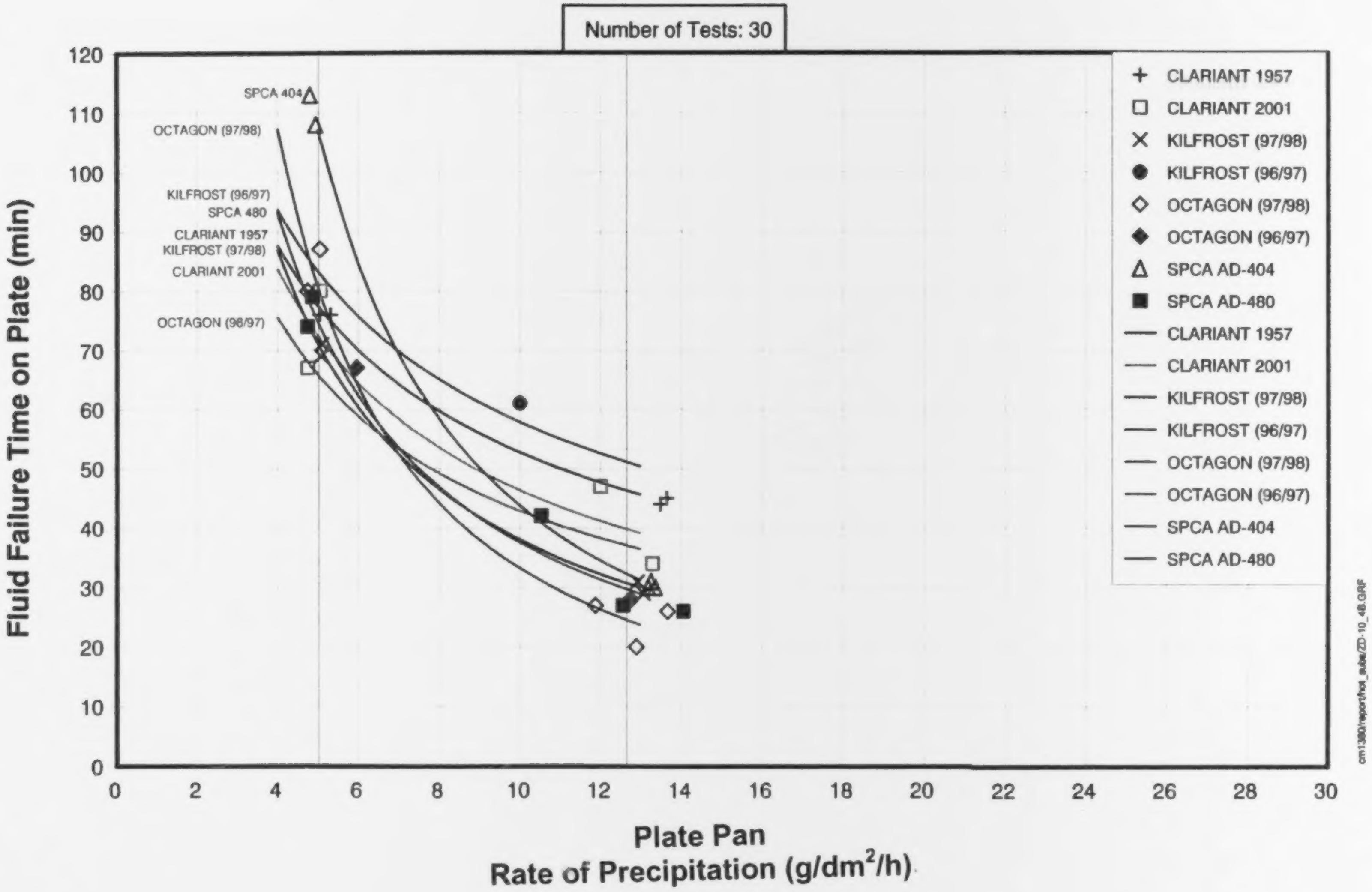
FREEZING DRIZZLE AT -10°C



EFFECT OF FLUID BRAND AND RATE OF PRECIPITATION ON FAILURE TIME

TYPE IV 75/25

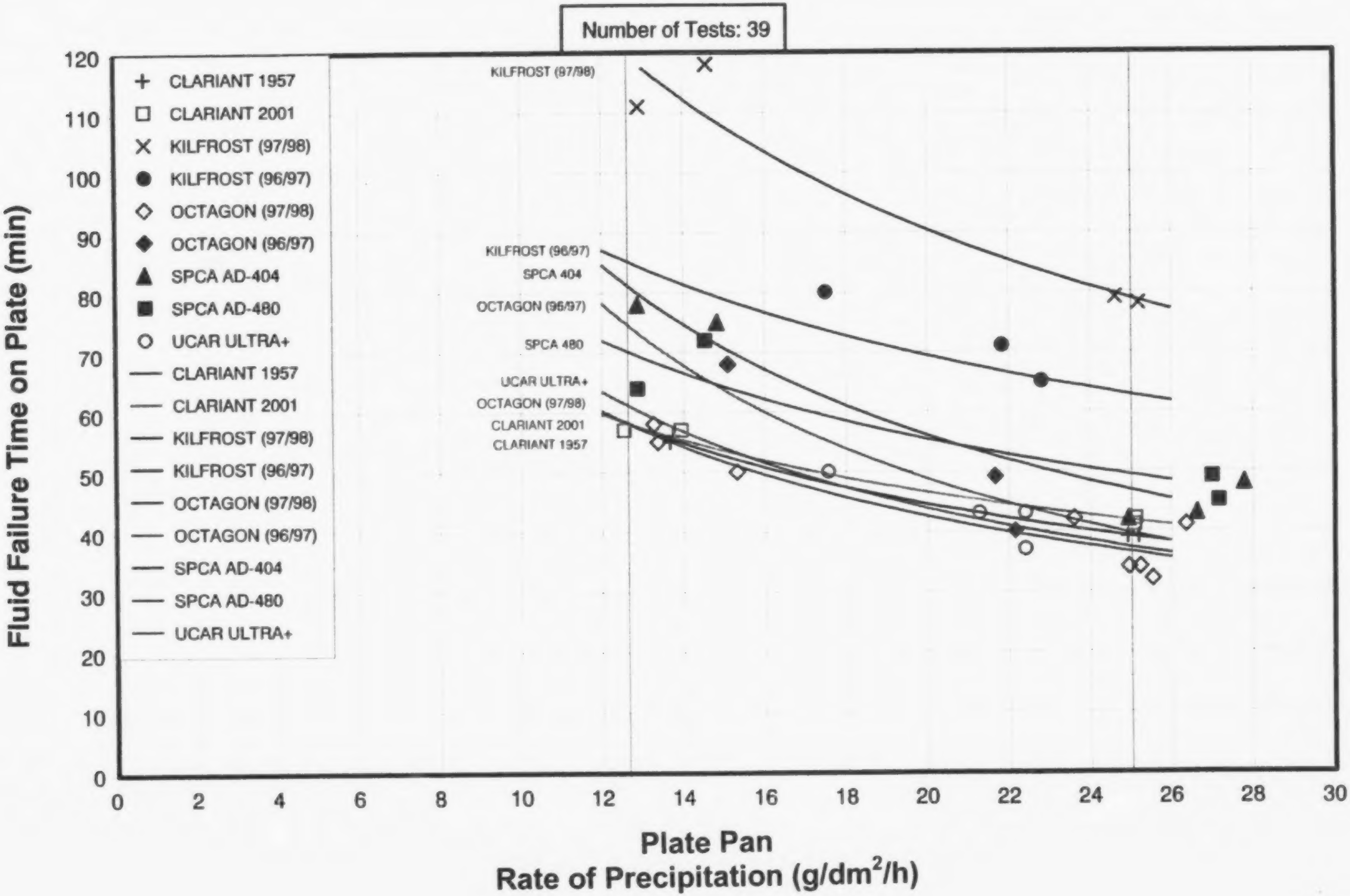
FREEZING DRIZZLE AT -10°C



EFFECT OF FLUID BRAND AND RATE OF PRECIPITATION ON FAILURE TIME

TYPE IV NEAT

LIGHT FREEZING RAIN AT -3°C

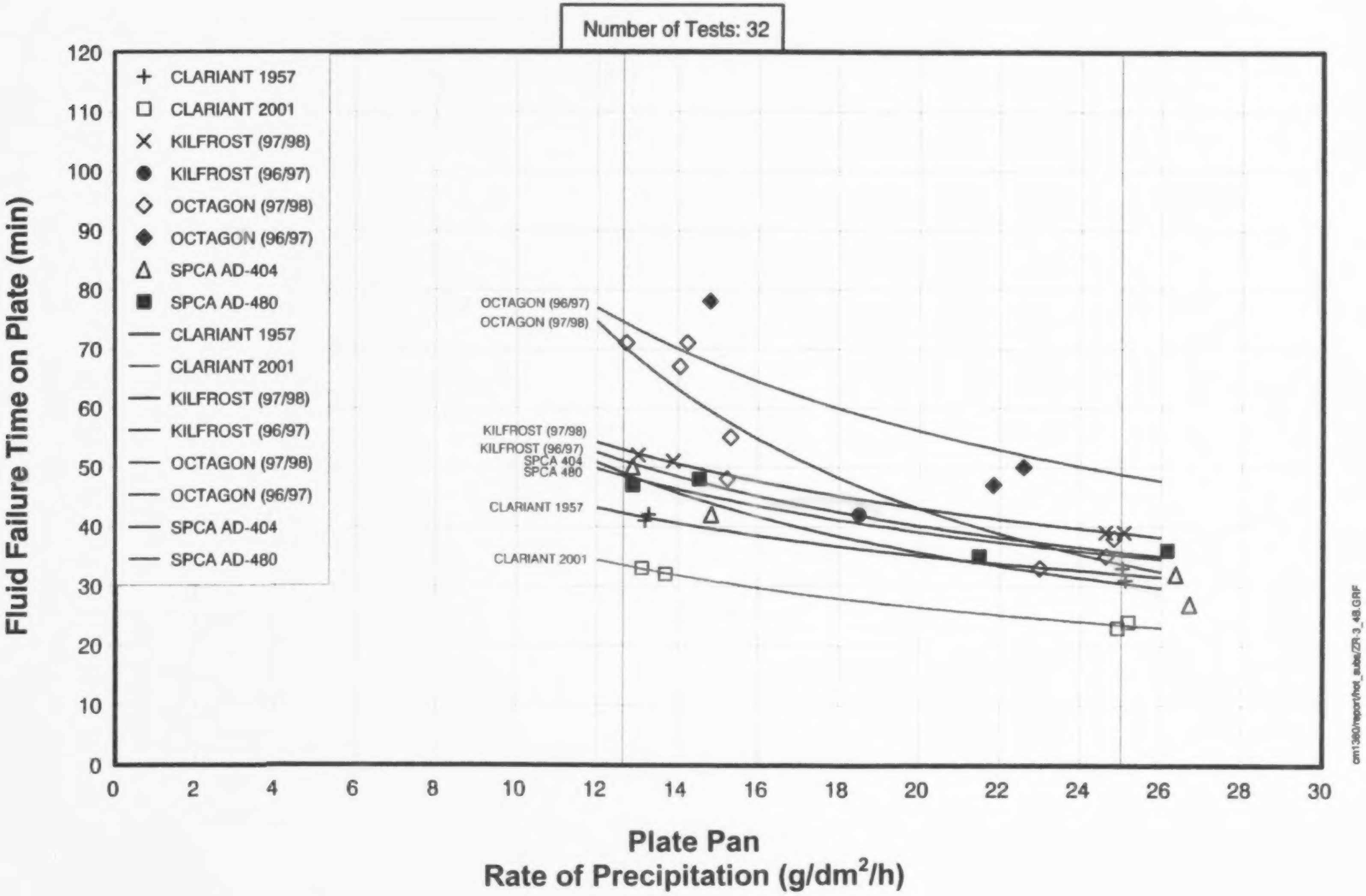


cm1380/report/hot_subs/ZR-3_4N.GRF

EFFECT OF FLUID BRAND AND RATE OF PRECIPITATION ON FAILURE TIME

TYPE IV 75/25

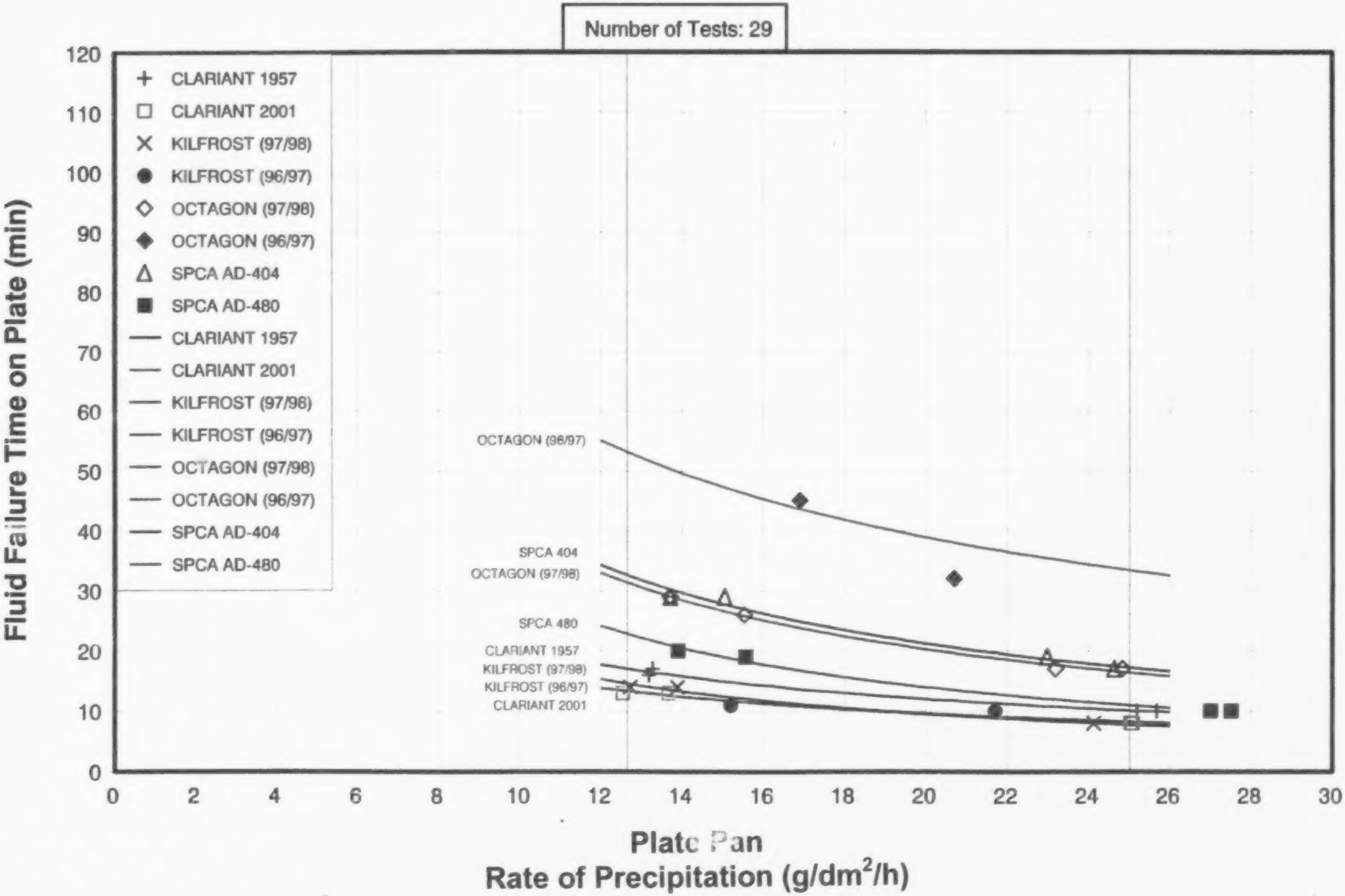
LIGHT FREEZING RAIN AT -3°C



EFFECT OF FLUID BRAND AND RATE OF PRECIPITATION ON FAILURE TIME

TYPE IV 50/50

LIGHT FREEZING RAIN AT -3°C

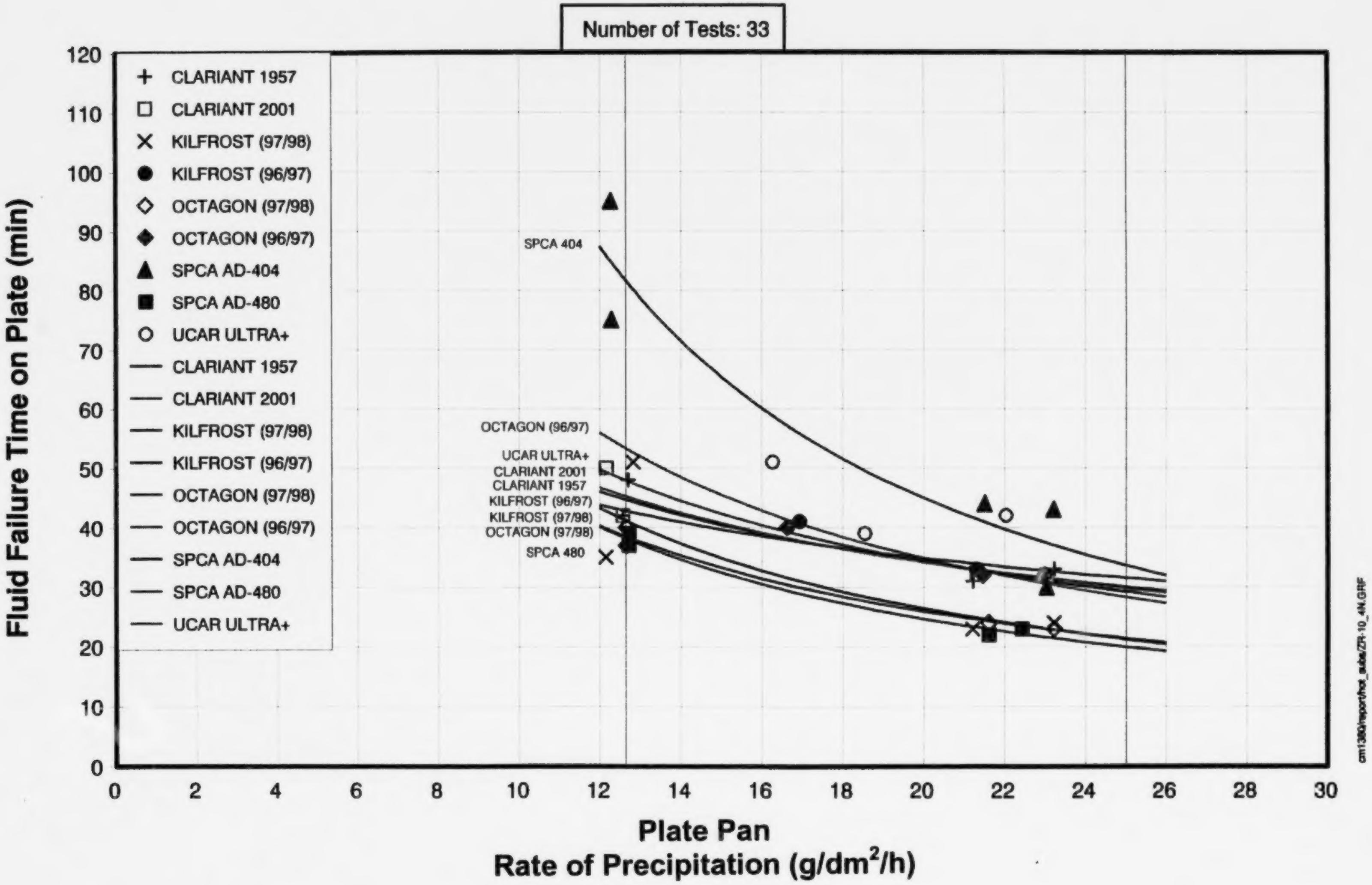


cm1380/report/hot_sube/ZR-3_4e.GRF

EFFECT OF FLUID BRAND AND RATE OF PRECIPITATION ON FAILURE TIME

TYPE IV NEAT

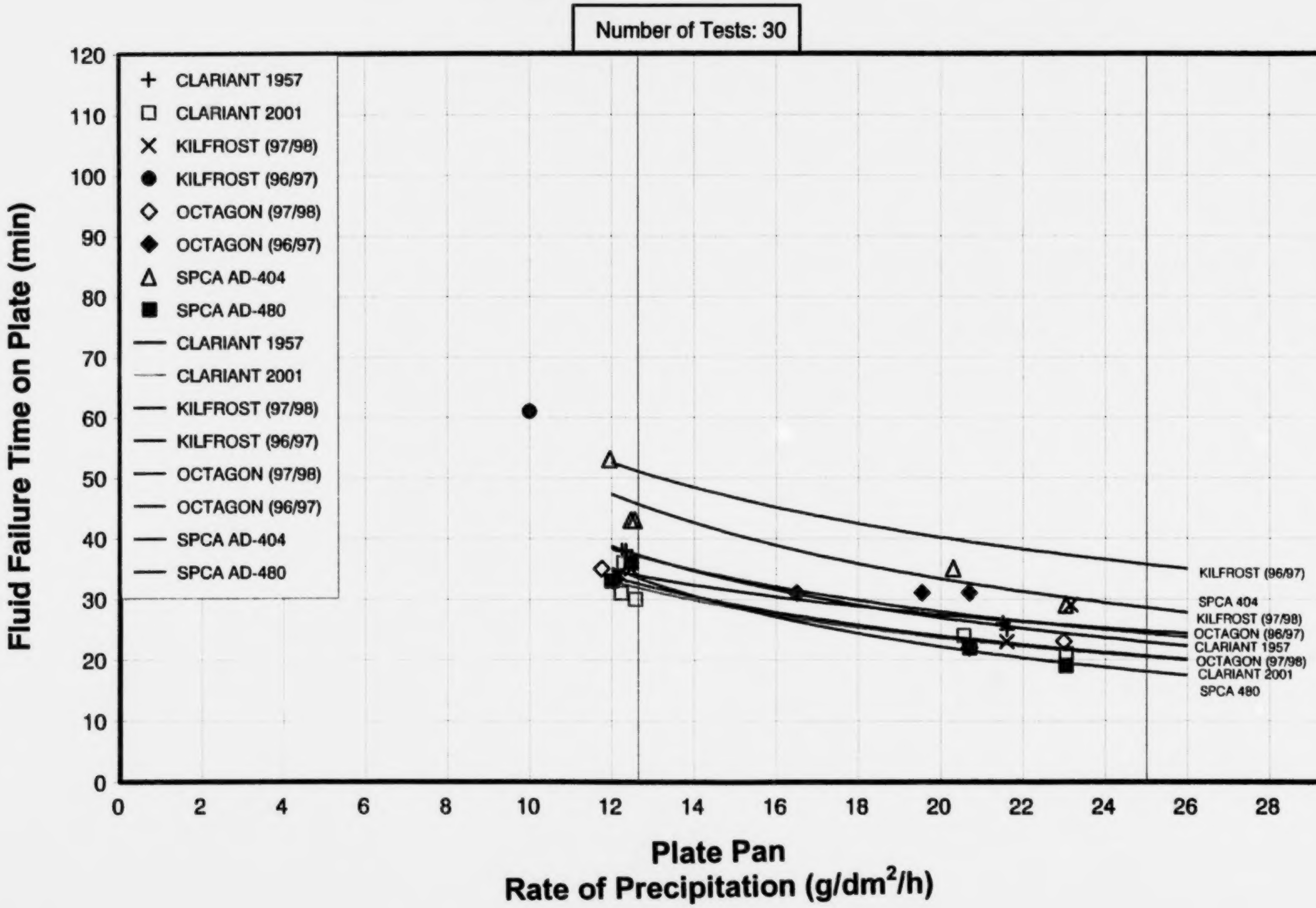
LIGHT FREEZING RAIN AT -10°C



EFFECT OF FLUID BRAND AND RATE OF PRECIPITATION ON FAILURE TIME

TYPE IV 75/25

LIGHT FREEZING RAIN AT -10°C

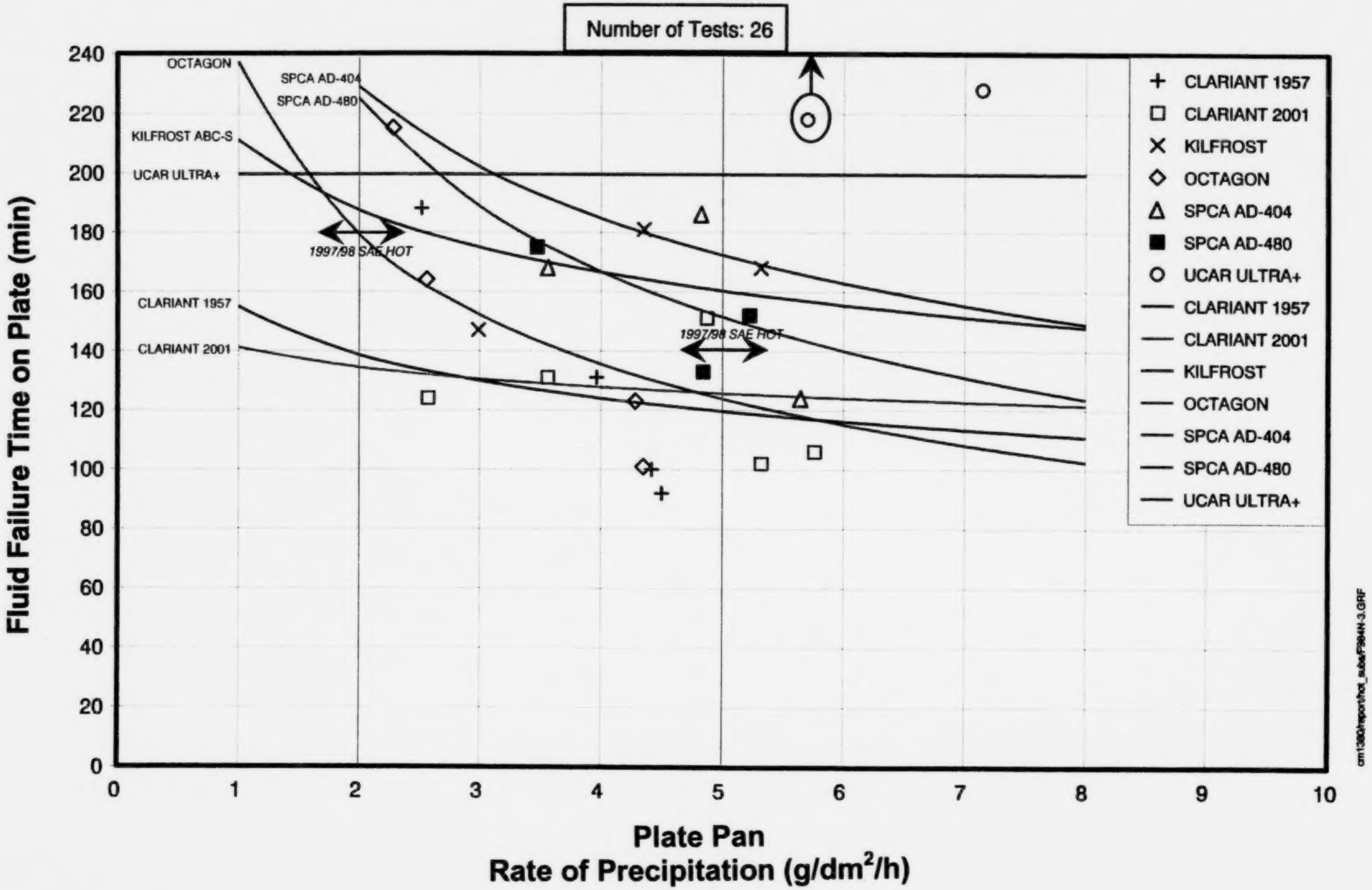


cm1380/report/hot_subs/ZR-10_48.GRF

EFFECT OF FLUID BRAND AND RATE OF PRECIPITATION ON FAILURE TIME

TYPE IV NEAT AT -3°C

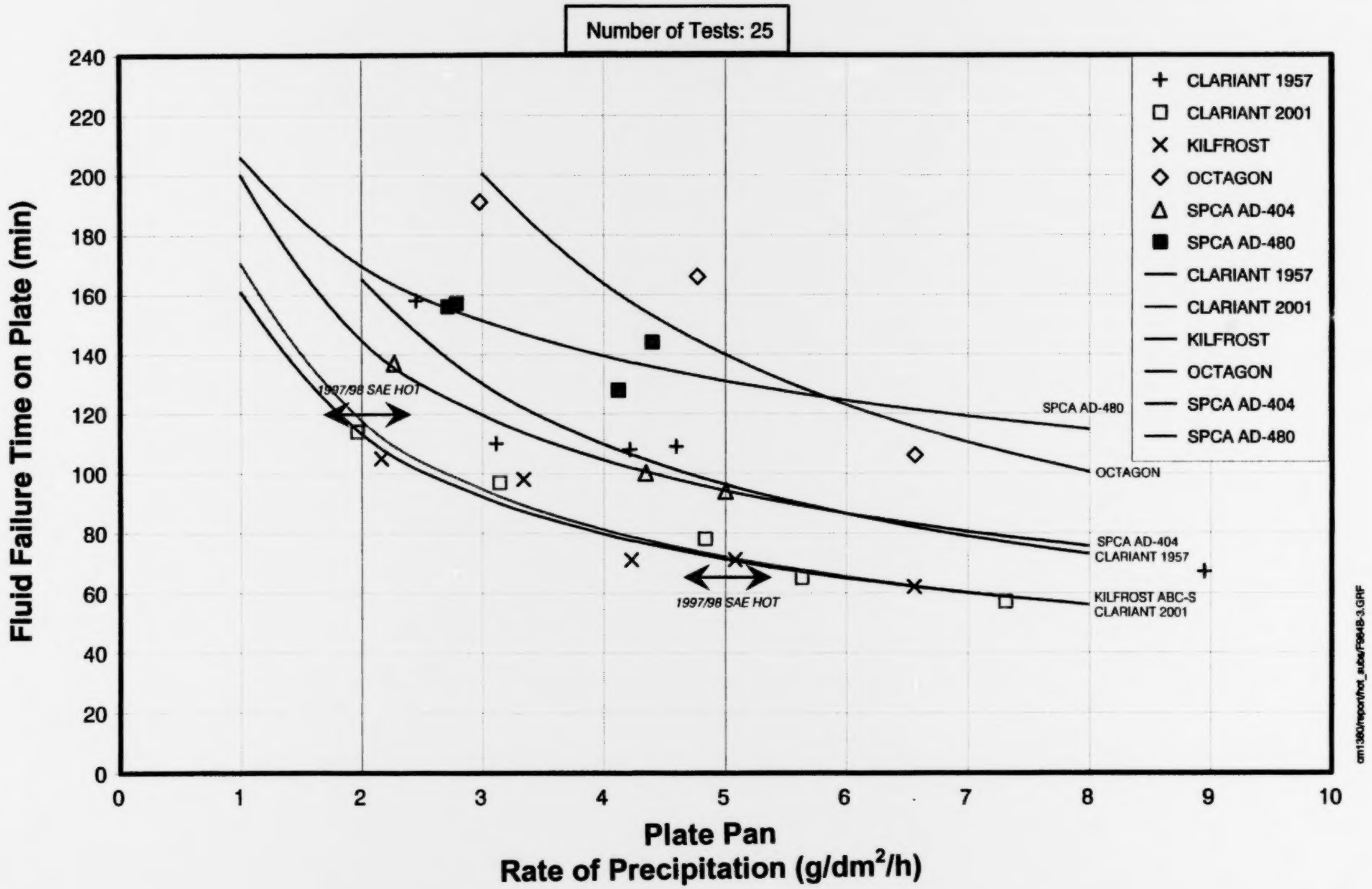
SIMULATED FREEZING FOG



EFFECT OF FLUID BRAND AND RATE OF PRECIPITATION ON FAILURE TIME

TYPE IV 75/25 AT -3°C

SIMULATED FREEZING FOG

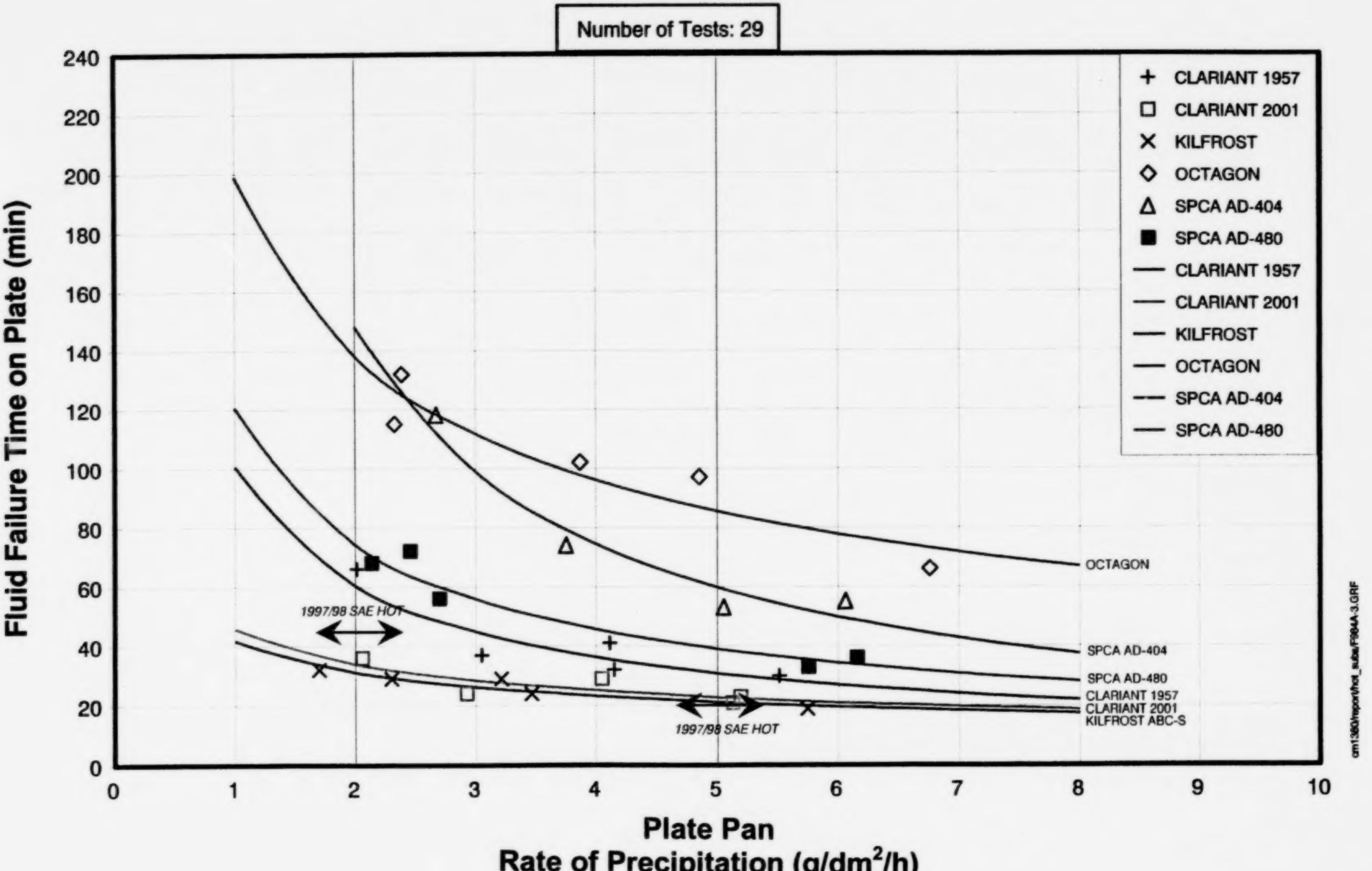


cm1380/report/hot_subs/F9848-3.GRF

EFFECT OF FLUID BRAND AND RATE OF PRECIPITATION ON FAILURE TIME

TYPE IV 50/50 AT -3°C

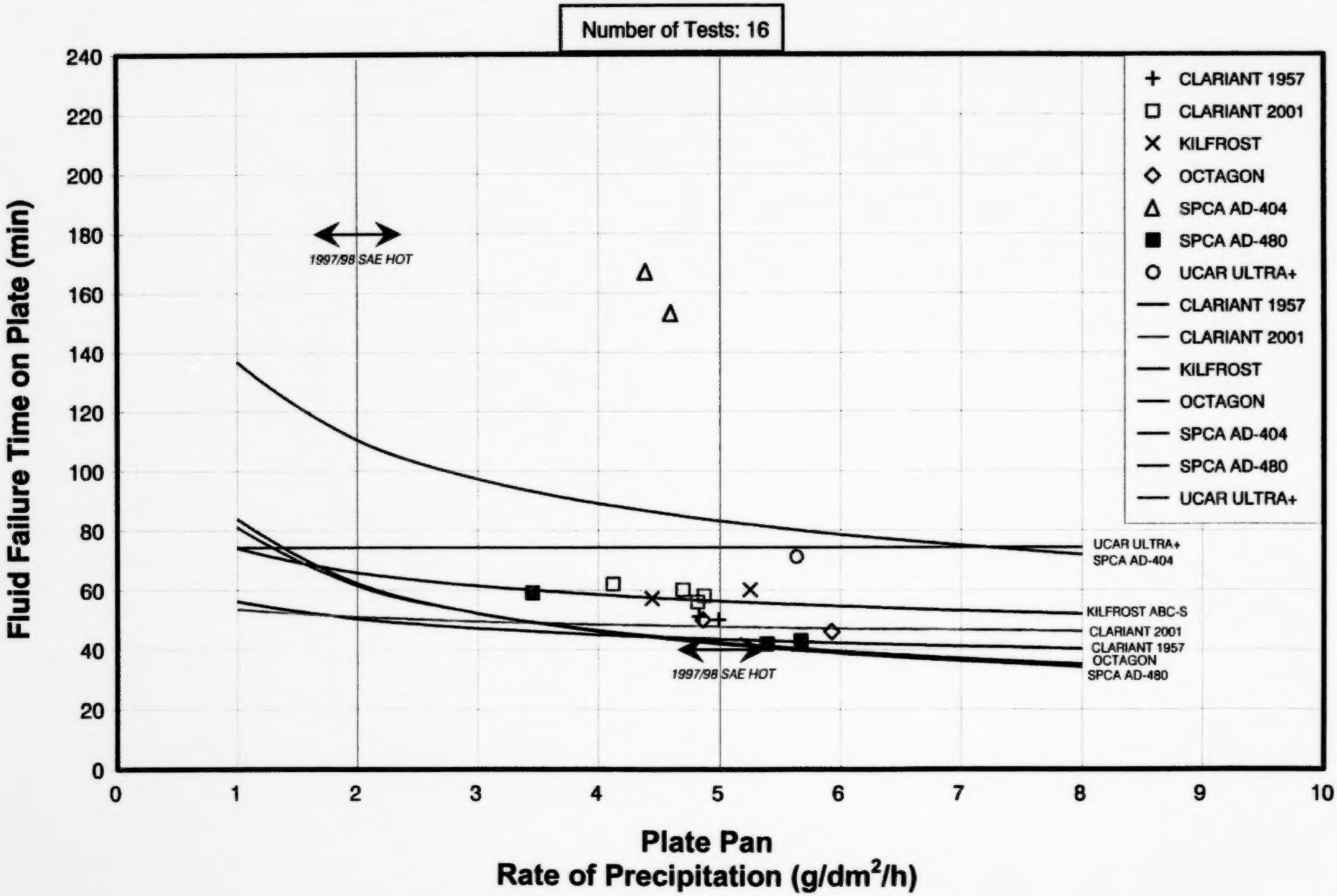
SIMULATED FREEZING FOG



EFFECT OF FLUID BRAND AND RATE OF PRECIPITATION ON FAILURE TIME

TYPE IV NEAT AT -14°C

SIMULATED FREEZING FOG

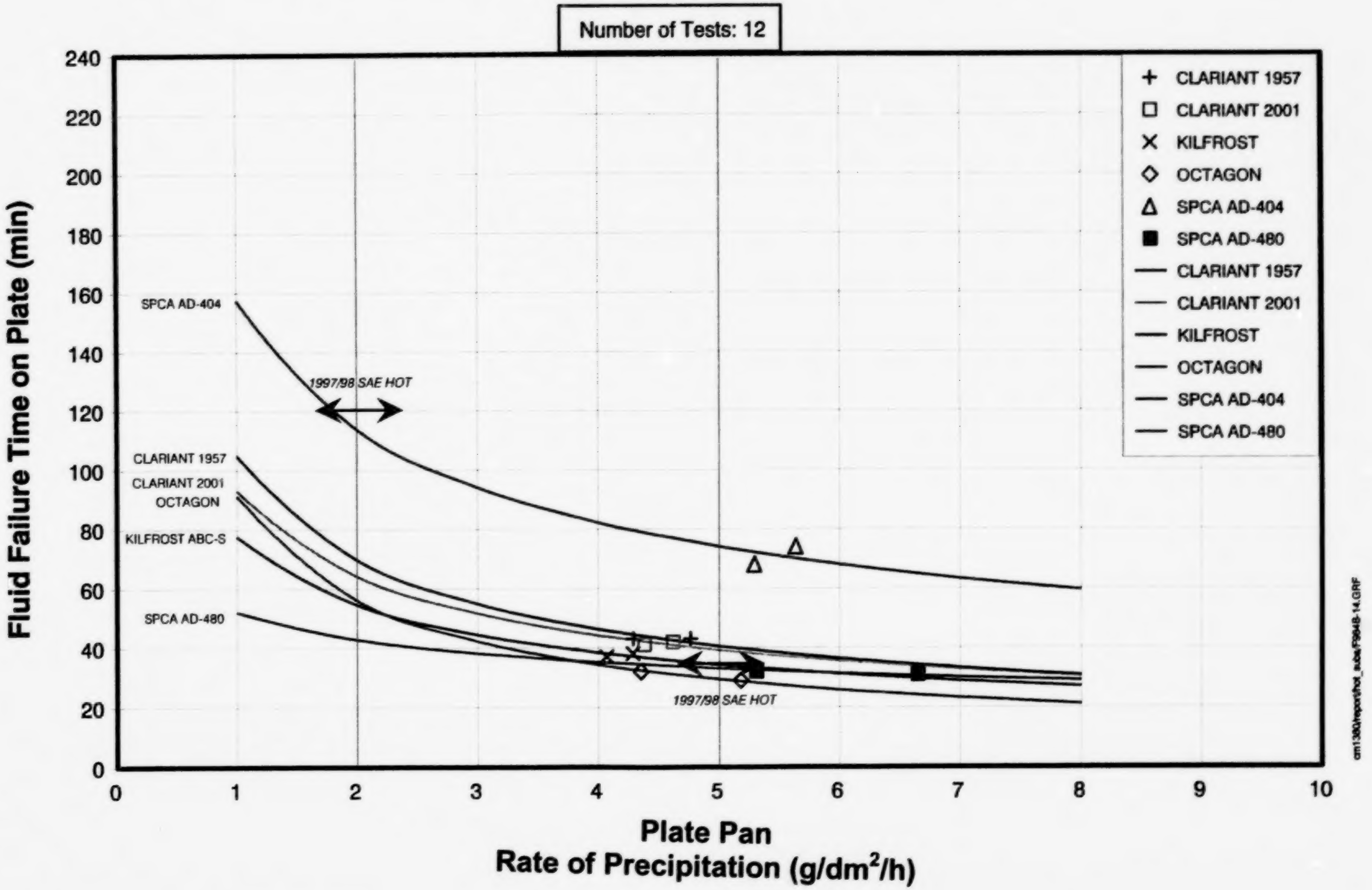


cm1380/report/hot_subs/FS84N-14.GRF

EFFECT OF FLUID BRAND AND RATE OF PRECIPITATION ON FAILURE TIME

TYPE IV 75/25 AT -14°C

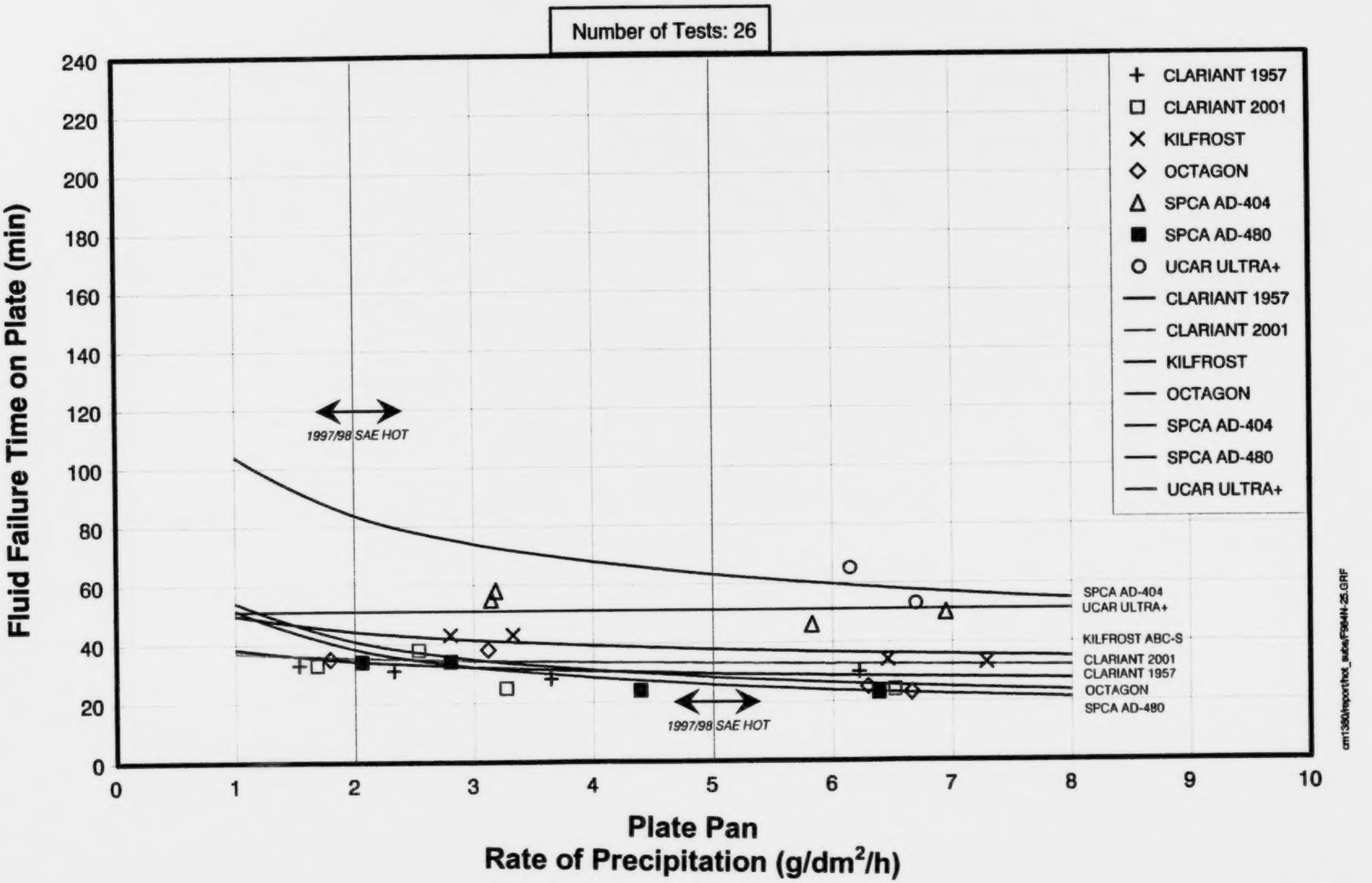
SIMULATED FREEZING FOG



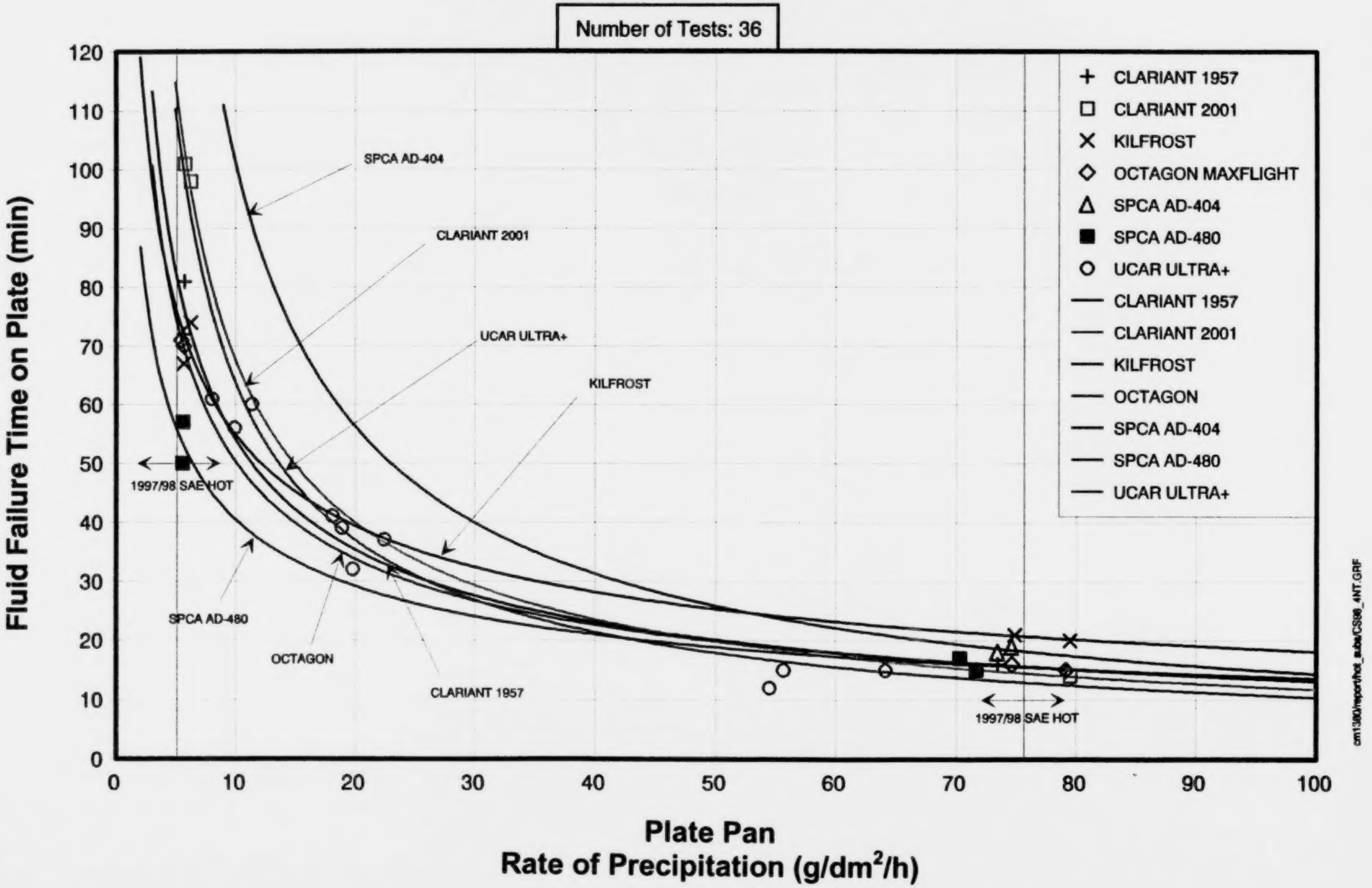
EFFECT OF FLUID BRAND AND RATE OF PRECIPITATION ON FAILURE TIME

TYPE IV NEAT AT -25°C

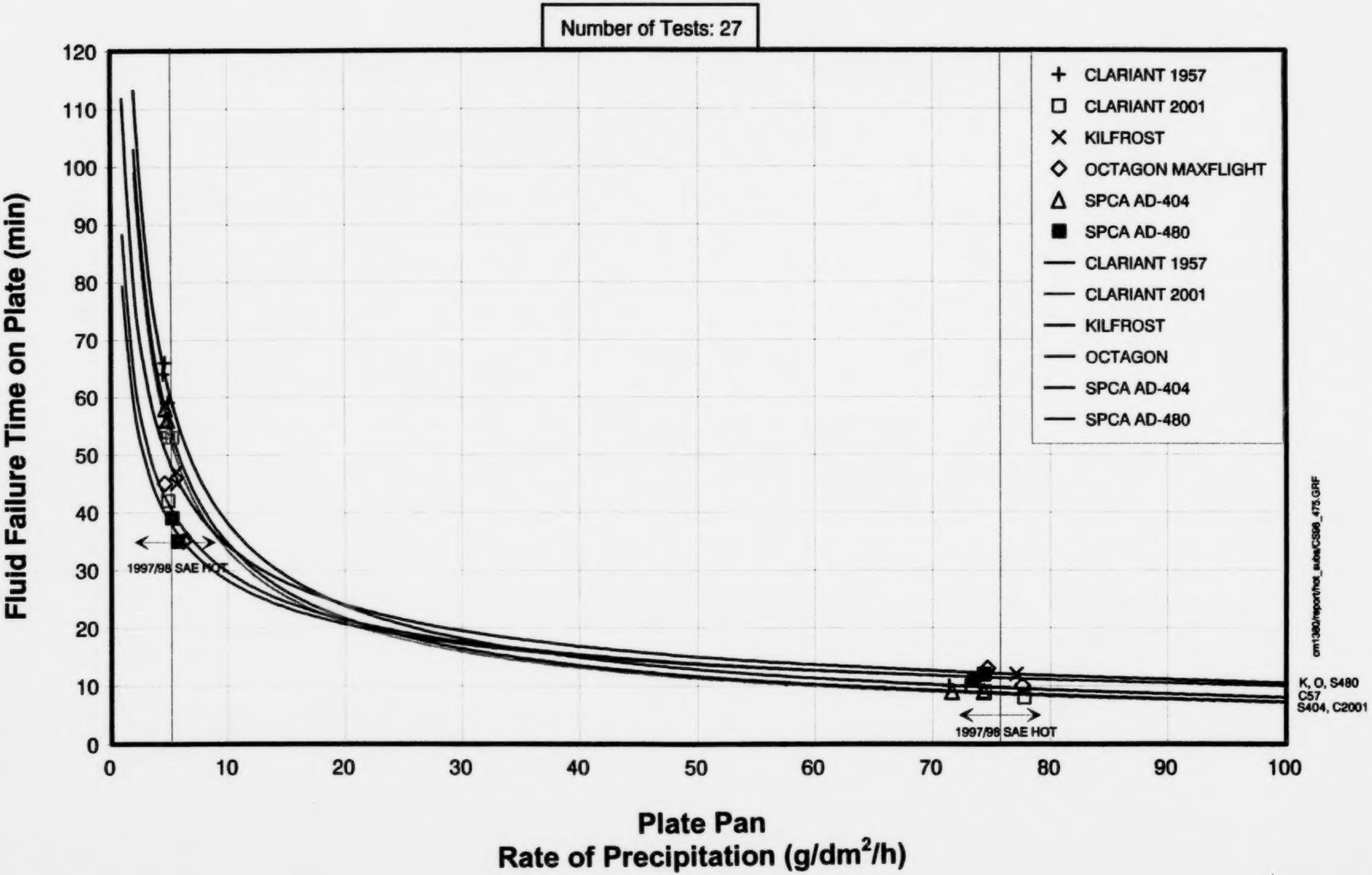
SIMULATED FREEZING FOG



EFFECT OF FLUID BRAND AND RATE OF PRECIPITATION ON FAILURE TIME
TYPE IV NEAT
RAIN ON COLD-SOAKED SURFACE



EFFECT OF FLUID BRAND AND RATE OF PRECIPITATION ON FAILURE TIME
TYPE IV 75/25
RAIN ON COLD-SOAKED SURFACE



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APPENDIX S

AIRCRAFT ICING-RELATED ACCIDENT/INCIDENT DATABASE

AIRCRAFT ICING ACCIDENT/INCIDENT DATABASE (Pg. 1/17)

ID code	ID #	Month	Day	Year	Date (dd-mmm-yy)	Code	A/C Type	A/C Type	Data base	Data base ref#	Data source 1	Data Source 2	Data Source 3	DatRef 1	DatRef 2	DatRef 3	Operator	Location	State	Country
I	10	11	23	1976	23-Nov-76	DW	NAMC-YS-11A		ICAO	76/0326-0								SERVIA-KOZANI		GREECE
W	219	1	16	1977	16-Jan-77	DW	Cessna 185		TC (Icing)	A77W0003							Reindeer Air Service Ltd	Cape Parry	N W T	Canada
W	202	2	26	1977	26-Feb-77	DW	Douglas DC-3C-S1C3G		TC (Icing)	A77H0001							Survair Ltd	Bagot	Quebec	Canada
W	215	3	4	1977	4-Mar-77	DW	Piper PA-31T		TC (Icing)	A77P0013								Terrason Lake	British Columbia	Canada
W	216	3	20	1977	20-Mar-77	DW	Piper PA-22-160		TC (Icing)	A77P0003								Kechika River	British Columbia	Canada
W	11	1	21	1979	21-Jan-79	DW	Cessna 172 M		TC (Walper)	A79W0004								Kinuso	Alberta	Canada
W	17	12	30	1980	30-Dec-80	DW	Cessna 185		TC (Walper)	A80C4053								Falls	Ontario	Canada
W	23	10	16	1981	16-Oct-81	DW	Bell 206 Jetranger		TC (Walper)	A81O0091							Lakeland Helicopters	Ramsey	Ontario	Canada
W	29	3	29	1982	29-Mar-82	DW	Piper PA-28		TC (Walper)	A82W0011								Hussar	Alberta	Canada
W	36	5	6	1983	6-May-83	DW	Cessna 180 J		TC (Walper)	A83P0002								Naka Creek	British Columbia	Canada
E	113	8	25	1984	25-Aug-84	DW	Rockwell	Turbo Commander	EURICE		ICAO	-	-	84/0267-0	-	-		?	?	USA
W	46	9	10	1984	10-Sep-84	DW	Piper PA-32		TC (Walper)	A84W0004								Summit Lake	British Columbia	Canada
W	60	2	15	1985	15-Feb-85	DW	DeHavilland DHC-2 MK I		TC (Walper)	A85A0002							Newfoundland Air Transport Ltd	Fortune	Newfoundland	Canada
W	64	11	26	1985	26-Nov-85	DW	Cessna 170 B		TC (Walper)	A85P0062								Unknown	British Columbia	Canada
W	61	9	30	1985	30-Sep-85	DW	Hughes 269		TC (Walper)	A85Q0049							Agriculture spraying Services	Lac des Brumes	Quebec	Canada
S	2	3		1986	Mar-86	DW	LRG		NASA	83241								BCY	TX	
S	13	8		1986	Aug-86	DW	LRG		NASA	119418								BIH	CA	
W	87	9	6	1986	6-Sep-86	DW	Piper PA-32		TC (Walper)	A86Q0242								Wabush	Quebec	Canada
W	82	12	6	1986	6-Dec-86	DW	Piper PA-28		TC (Walper)	A86A0270								North Atlantic	North Atlantic	Canada
W	122	4	29	1984	29-Apr-84	DW	Cessna 172		TC (Walper)	A84A0080								St John's	Newfoundland	Canada
W	180	5	10	1986	10-May-86	DW	Antonov AN-24 \ Piper PA-28		TC (Walper)	A86A0071							Air Cubana \ Ermaky	North Atlantic	North Atlantic	Canada
W	176	12	7	1987	7-Dec-87	DW	Beech 100		TC (Walper)	A87C0236							Voyageur Airways Ltd	Sioux Lookout	Ontario	Canada
F	42	3	18	1968	18-Mar-68	EI	Gates Learjet		FSF								Mutual Insurance		Lake Michigan	
F	47	7	1	1968	1-Jul-68	EI	ero Commander Jet Commander		FSF									Drake Field	Arkansas	
E	476	2	4	1970	4-Feb-70	EI	Nord	262	EURICE		CAA WAAS	-	-	-	-	-	Rousseau Aviation	Nr Paris	—	France
I	1	2	4	1970	4-Feb-70	EI	NORD 262		ICAO	70/0009-0							Rousseau Aviation	Nr Paris	—	France
E	471	12	29	1971	29-Dec-71	EI	BAe	125	EURICE		BAe	-	-	-	-	-		?	?	?
E	469	1	27	1972	27-Jan-72	EI	BAe	125	EURICE		BAe	-	-	-	-	-		?	?	?
E	468	10	27	1972	27-Oct-72	EI	BAe	125	EURICE		BAe	-	-	-	-	-		?	?	?
E	466	11	28	1972	28-Nov-72	EI	Douglas	DC-8	EURICE		CAA WAAS	-	-	-	-	-	Japan Airlines	Moscow	—	USSR
E	463	12	12	1972	12-Dec-72	EI	Lear	Learjet	EURICE		CAA WAAS	-	-	-	-	-	Zantop Air Transport	Ypsilanti	Michigan	USA
E	460	2	16	1973	16-Feb-73	EI	BAe	125	EURICE		BAe	-	-	-	-	-		?	?	?
E	461	5	24	1973	24-May-73	EI	BAe	125	EURICE		BAe	-	-	-	-	-		?	?	?
I	5	12	30	1973	30-Dec-73	EI	MCDONNELL-DOUGLAS DC-9		ICAO	73/1495-0								SPRINGFIELD		UNITED STATES
E	456	1	16	1974	16-Jan-74	EI	BAe	125	EURICE		BAe	-	-	-	-	-		?	?	?
E	457	2	27	1974	27-Feb-74	EI	BAe	125	EURICE		BAe	-	-	-	-	-		?	?	?
E	447	1	18	1975	18-Jan-75	EI	Curtiss	C-46	EURICE		CAA WAAS	-	-	-	-	-	Aerovias Las Minas	Nr La Paz	—	Bolivia
E	449	7	13	1975	13-Jul-75	EI	BAe	125	EURICE		BAe	-	-	-	-	-		?	?	?
E	443	4	19	1975	19-Apr-75	EI	BAe	125	EURICE		BAe	-	-	-	-	-		?	?	?
E	442			1976		EI	Vickers	Viscount	EURICE		CAA WAAS	-	-	-	-			?	?	?
E	446			1976		EI	Vickers	Viscount	EURICE		?	-	-	-	-	-		?	?	?
W	214	1	9	1977	9-Jan-77	EI	Rockwell Commander 100-180		TC (Icing)	A77P0002								Mabel Lake	British Columbia	Canada
E	438	1	17	1977	17-Jan-77	EI	BAe	125	EURICE		BAe	-	-	-	-	-		?	?	?
E	430	3	22	1977	22-Mar-77	EI	BAe	125	EURICE		BAe	-	-	-	-	-		?	?	?
W	221	4	8	1977	8-Apr-77	EI	Cessna 172 M		TC (Icing)	A77W0024								Crimson Lake	Alberta	Canada
W	207	5	8	1977	8-May-77	EI	Bell 206 Jetranger		TC (Icing)	A77C0039							Ontario Provincial Police	Coshill	Ontario	Canada
W	196	5	27	1977	27-May-77	EI	Cessna 180 J		TC (Icing)	A77C0085								Minaki	Ontario	Canada
W	191	7	12	1977	12-Jul-77	EI	Grumman G-164A MK II		TC (Icing)	A77A0022							Forest Protection Ltd	Edmundston	New Brunswick	Canada
E	431	7	20	1977	20-Jul-77	EI	BAe	125	EURICE		BAe	-	-	-	-	-		?	?	?
W	220	9	2	1977	2-Sep-77	EI	Cessna 177 A		TC (Icing)	A77W0008								Edson	Alberta	Canada
E	432	11	16	1977	16-Nov-77	EI	BAe	125	EURICE		BAe	-	-	-	-	-		?	?	?
W	223	11	19	1977	19-Nov-77	EI	Piper PA-24		TC (Icing)	A77W0117								Red Deer	Alberta	Canada
W	209	11	23	1977	23-Nov-77	EI	Stinson 108		TC (Icing)	A77O0116								Lake Simcoe	Ontario	Canada
I	20	12	14	1977	14-Dec-77	EI	NORTH AMERICAN-SABRE 75		ICAO	77/0471-0								TEHRAN/MEHRABAD		IRAN ISLAMIC REPUBLIC OF
W	225	12	17	1977	17-Dec-77	EI	Cessna 170 B		TC (Icing)	A77W0120								Ft Simpson	N W T	Canada
W	210	12	31	1977	31-Dec-77	EI	Cessna 172 M		TC (Icing)	A77O0130								Timmins	Ontario	Canada
E	427	3	7	1978	7-Mar-78	EI	BAe	125	EURICE		BAe	CAA	-	-	Occrum 78008EBH	-	BFS	Dusseldorf	—	Germany
I	22	3	7	1978	7-Mar-78	EI	Hawker Siddeley HS125		ICAO	78/0029-0							BFS	Dusseldorf	—	Germany
E	423	3	27	1978	27-Mar-78	EI	BAe	125	EURICE		BAe	-	-	-	-	-		?	?	?
W	2	3	27	1978	27-Mar-78	EI	Beech 90		TC (Walper)	A78A0002								Indian Harbour	Newfoundland	Canada
E	424	5	6	1978	6-May-78	EI	BAe	125	EURICE		BAe	-	-	-	-	-		?	?	?
E	420	6	19	1978	19-Jun-78	EI	BAe	125	EURICE		BAe	-	-	-	-	-		?	?	?
E	421	6	29	1978	29-Jun-78	EI	BAe	125	EURICE		BAe	-	-	-	-	-		?	?	?
W	4	8	19	1978	19-Aug-78	EI	Bell 206 Jetranger		TC (Walper)	A78P0087							Liftair International Ltd	Mt Helvetia	British Columbia	Canada
E	412	12	7	1978	7-Dec-78	EI	Bae	125	EURICE		CAA WAAS	-	-	None	-	-		?	?	?
E	419			1978		EI	BAe	125	EURICE		BAe	-	-	-	-	-		?	?	?
E	425			1978		EI	BAe	125	EURICE		BAe	-	-	-	-	-		?	?	?
E	428			1978		EI	Handley Page	Herald	EURICE		CAA WAAS	-	-	-	-	-		?	?	?
E	411	2	9	1979	9-Feb-79	EI	Bae	125	EURICE		CAA WAAS	-	-	None	-	-		?	?	?
E	410	3	9	1979	9-Mar-79	EI	Bae	125	EURICE		CAA WAAS	-	-	None	-	-		?	?	?
E	4			1980		EI	Bae	125	EURICE		CAA	-	-	Occrum 8000439C	-	-	British Aircraft Corp	?	?	?
E	9			1980		EI	Boeing	747	EURICE		CAA	-	-	Occrum 8001917X	-	-	British Airways	?	?	?
E	25	1	6	1981	6-Jan-81	EI	Fairchild	Metro	EURICE		FAA	-	-	135	-	-	Midstate Airlines	Chicago	Illinois	USA
E	26	1	7	1981	7-Jan-81	EI	Fairchild	Metro	EURICE		FAA	-	-	135	-	-	Air Wisconsin	Lincoln	Nebraska	USA
E	33	12	16	1981	16-Dec-81	EI	Boeing	727	EURICE		ICAO	Bas	-	81/2108-0	None	-	Sterling Airways	Gander	Newfoundland	Canada
I	37	12	16	1981	16-Dec-81	EI	Boeing 727-200		ICAO	81/2108-0							Sterling Airways	Gander	Newfoundland	Canada
E	36	12	22	1981	22-Dec-81	EI	Fairchild	Metro	EURICE		FAA	-	-	135	-	-	Avair	Roanoke	Virginia	USA
E	38	12	22	1981	22-Dec-81	EI	Fairchild	Metro	EURICE		FAA	-	-	135	-	-	Avair	Roanoke	Virginia	USA

AIRCRAFT ICING ACCIDENT/INCIDENT DATABASE (Pg. 2/17)

ID code	ID #	Month	Day	Year	Date (dd-mmm-yy)	Code	A/C Type	A/C Type	Data base	Data base ref#	Data source 1	Data Source 2	Data Source 3	DatRef 1	DatRef 2	DatRef 3	Operator	Location	State	Country
E	45	1	8	1982	8-Jan-82	EI	Bae	125	EURICE		Bae	–	–	None	–	–	Shell Aviation	London		UK
E	48	1	13	1982	13-Jan-82	EI	Fairchild	Metro	EURICE		FAA	–	–	135	–	–	Avair	Richmond	Virginia	USA
E	51	1	14	1982	14-Jan-82	EI	Mitsubishi	MU-2	EURICE		FAA	–	–	091	–	–		Longview	Texas	USA
E	55	2	9	1982	9-Feb-82	EI	Rockwell	Commander 500	EURICE		FAA	–	–	135	–	–	Central Airlines	Buffalo	New York	USA
E	57	4	6	1982	6-Apr-82	EI	Fairchild	Metro	EURICE		FAA	–	–	135	–	–	Empire Airlines	Syracuse	New York	USA
E	37			1982		EI	British Aircraft Corp	111	EURICE		CAA	–	–	Occrum 8203259J	–	–	British Airways	Alicante		Spain
E	39			1982		EI	Short	330	EURICE		CAA	–	–	Occrum 8200730F	–	–	Inter City Airways	East Midlands Apt	Midlands	UK
E	42			1982		EI	Handley Page	Herald	EURICE		CAA	–	–	Occrum 82 00801F	–	–	Brymon Airways	?	?	?
E	43			1982		EI	de Havilland	Trident	EURICE		CAA	–	–	Occrum 82 01326D	–	–	British Airways	Lambourne	?	UK
E	73	2	7	1983	7-Feb-83	EI	McDonnell-Douglas	DC-9	EURICE		FAA	–	–	121	–	–	New York Airlines	Boston	Massachusetts	USA
E	75	3	21	1983	21-Mar-83	EI	Fairchild	Metro	EURICE		FAA	–	–	121	–	–	Britt Airways	Chicago	Illinois	USA
E	76	3	21	1983	21-Mar-83	EI	Fairchild	Metro	EURICE		FAA	–	–	135	–	–	Midstate Airlines	Chicago	Illinois	USA
E	77	4	15	1983	15-Apr-83	EI	Boeing	707	EURICE		FAA	–	–	121	–	–	Global International A/W	Minneapolis	Minnesota	USA
E	78	8	20	1983	20-Aug-83	EI	Boeing	767	EURICE		Bae	–	–	None	–	–	United Airlines	Nr Denver	Colorado	USA
W	38	10	1	1983	1-Oct-83	EI	Aeronca 7DC		TC (Walper)	A83Q0009								Bagotville	Quebec	Canada
E	80	11	23	1983	23-Nov-83	EI	Bae	125	EURICE		Bae	–	–	None	–	–	Rank Xerox	London		UK
E	82	12	28	1983	28-Dec-83	EI	Fairchild	Metro	EURICE		FAA	–	–	121	–	–	Britt Airways	Evansville	Indiana	USA
E	62			1983		EI	Short	360	EURICE		CAA	–	–	Occrum 83038938	–	–	Simmonds Airlines	Iron Mountain	Michigan	USA
E	79			1983		EI	Boeing	747	EURICE		Bae	–	–	None	–	–		?	?	?
E	99	1	11	1984	11-Jan-84	EI	Bae	125	EURICE		Bae	–	–	None	–	–	Gecamines	Nr Kinshasa	?	Zaire
E	102	1	13	1984	13-Jan-84	EI	Fokker	F27	EURICE		ICAO	NTSB	NLR	84/0367-0	1567	None	Pilgrim Airlines	Jamaica	New York	USA
E	106	2	1	1984	1-Feb-84	EI	Boeing	727	EURICE		FAA	–	–	121	–	–	Pan American Airways	Newark	New Jersey	USA
E	110	4	29	1984	29-Apr-84	EI	Boeing	727	EURICE		FAA	–	–	121	–	–	Northwest Airlines	Minneapolis	Minnesota	USA
E	111	4	29	1984	29-Apr-84	EI	McDonnell-Douglas	DC-9	EURICE		FAA	–	–	121	–	–	Midway Airlines	Minneapolis	Minnesota	USA
E	112	4	30	1984	30-Apr-84	EI	Boeing	727	EURICE		FAA	–	–	121	–	–	Eastern Airlines	Minneapolis	Minnesota	USA
W	44	9	28	1984	28-Sep-84	EI	Cessna 180 A		TC (Walper)	A84Q0080								Kanawata Aeropark	Quebec	Canada
E	114	10	21	1984	21-Oct-84	EI	Beech	99	EURICE		ICAO	–	–	84/0195-0	–	–		?	?	USA
W	45	11	26	1984	26-Nov-84	EI	Tartom Tiara II		TC (Walper)	A84Q0008							Avions Ultra Legers V Fontaine	Mont Laurier AP	Quebec	Canada
I	61	12	14	1984	14-Dec-84	EI	EROSPATIALE-SA 330J PUMA		ICAO	84/0345-0								ABERDEEN A/P		UNITED KINGDOM
E	121	12	19	1984	19-Dec-84	EI	Cessna	401	EURICE		ICAO	NTSB	–	84/0261-0	2846	–	Hawkins Air	Tonopah	Nevada	USA
E	86			1984		EI	Short	360	EURICE		CAA	–	–	Occrum 8404087D	–	–	Simmonds Airlines	?	?	USA
E	95			1984		EI	Saab	SF340	EURICE		CAA	–	–	Occrum 8404031F	–	–		?	?	?
E	129	1	8	1985	8-Jan-85	EI	Fairchild	Metro	EURICE		ICAO	Bae	–	85/1046-0	None	–		?	Kentucky	USA
E	130	1	8	1985	8-Jan-85	EI	Cessna	Titan	EURICE		ICAO	NTSB	–	85/0009-0	387	–	Regional Express	Salt Lake City	Utah	USA
I	52	1	8	1985	8-Jan-85	EI	VEARINGEN-SA227AC/METRO III		ICAO	85/1048-0								COVINGTON		UNITED STATES
E	131	1	31	1985	31-Jan-85	EI	McDonnell-Douglas	DC-9	EURICE		ICAO	–	–	85/1047-0	–	–		?	?	USA
I	55	1	31	1985	31-Jan-85	EI	CDONNELL-DOUGLAS-DC-9-30		ICAO	85/1047-0								CHICAGO		UNITED STATES
E	132	2	1	1985	1-Feb-85	EI	Tupolev	Tu-134	EURICE		NLR	Bae	–	None	None	–	Aeroflot	Minsk		Bielorussia
E	136	2	11	1985	11-Feb-85	EI	Bae	Jetstream 31	EURICE		ICAO	Bae	–	85/1011-0	None	–		?	Georgia	USA
E	137	2	13	1985	13-Feb-85	EI	Fairchild	Metro	EURICE		ICAO	FAA	–	85/1186-0	135	–	Britt Airways	?	?	USA
E	138	2	24	1985	24-Feb-85	EI	McDonnell-Douglas	DC-9	EURICE		Trans Can	–	–	A8504028	–	–	Air Canada	Ottawa	Ontario	Canada
E	139	2	24	1985	24-Feb-85	EI	McDonnell-Douglas	DC-9	EURICE		Trans Can	–	–	A8504029	–	–	Air Canada	Ottawa	Ontario	Canada
E	140	3	5	1985	5-Mar-85	EI	McDonnell-Douglas	DC-10	EURICE		Trans Can	–	–	A8504803	–	–	CP Air	Toronto	Ontario	Canada
W	55	9	16	1985	16-Sep-85	EI	Cessna 180 J		TC (Walper)	A85P0909								Williams Lake	British Columbia	Canada
E	149	12	10	1985	10-Dec-85	EI	Saab	SF340	EURICE		FAA	–	–	121	–	–	Comair	Indianapolis	Indiana	USA
E	153	12	27	1985	27-Dec-85	EI	Cessna	401	EURICE		ICAO	FAA	–	85/1207-0	135	–	Regional Express	Spokane	Washington	USA
E	123			1985		EI	McDonnell-Douglas	DC-9	EURICE		CAA	–	–	Occrum 8503129G	–	–	Finnair	Helsinki		Finland
E	125			1985		EI	Bae	Jetstream 31	EURICE		CAA	–	–	Occrum 8500670C	–	–		?	?	?
E	126			1985		EI	Bae	Jetstream 31	EURICE		CAA	–	–	Occrum 8504648C	–	–		?	?	?
E	170	5	7	1986	7-May-86	EI	Rockwell	Turbo Commander	EURICE		ICAO	–	–	86/0148-0	–	–		?	?	USA
W	88	9	12	1986	12-Sep-86	EI	Beech 18		TC (Walper)	A86C0087							Rusty Myers Flying Service Ltd	Lower Manitou	Ontario	Canada
W	89	11	11	1986	11-Nov-86	EI	Cessna 182 M		TC (Walper)	A86O0005								Lake St Clair	Ontario	Canada
W	90	11	26	1986	26-Nov-86	EI	ipper-Formance Quicksilver MXL		TC (Walper)	A86P6006								Surrey	British Columbia	Canada
E	174	12	15	1986	15-Dec-86	EI	Antonov	An-24	EURICE		Bae	NLR	–	None	None	–	CAAC	Zhongchuan	–	China
E	177	12	25	1986	25-Dec-86	EI	McDonnell-Douglas	DC-9	EURICE		FAA	–	–	121	–	–	American Airlines	Cleveland	Ohio	USA
E	157			1986		EI	Bae	125	EURICE		CAA	–	–	Occrum 8604070G	–	–		Lubumbashi	?	?
E	183	3	17	1987	17-Mar-87	EI	Saab	SF340	EURICE		FAA	–	–	135	–	–	Express Airlines	Jackson	Mississippi	USA
E	186	6	11	1987	11-Jun-87	EI	Fairchild	Metro	EURICE		FAA	–	–	135	–	–	Big Sky Transportation	Spokane	Washington	USA
W	95	7	16	1987	16-Jul-87	EI	Cessna 182 M		TC (Walper)	A87C0005								Resolute Bay	N W T	Canada
E	191	11	22	1987	22-Nov-87	EI	Fairchild	Metro	EURICE		ICAO	NLR	–	87/0342-0	None	–	Air Littoral	Le Puy		France
E	194	12	17	1987	17-Dec-87	EI	Fairchild	Metro	EURICE		ICAO	NTSB	Bae	87/0423-0	2401	None	Avair	Chantilly	Virginia	USA
E	179			1987		EI	McDonnell-Douglas	DC-9	EURICE		CAA	–	–	Occrum 8702512D	–	–	British Midland Airways	?	?	?
E	188			1987		EI	Boeing	737	EURICE		Bae	–	–	None	–	–		Nr Salonika	—	Greece
E	206	1	24	1988	24-Jan-88	EI	Bae	Jetstream 31	EURICE		FAA	–	–	135	–	–	Metro Express	Columbus	Georgia	USA
E	208	2	12	1988	12-Feb-88	EI	McDonnell-Douglas	DC-9	EURICE		FAA	–	–	121	–	–	Continental Airlines	Washington	DC	USA
E	207	2	14	1988	14-Feb-88	EI	De Havilland Canada	Dash 8	EURICE		Trans Can	–	–	A88A0039	–	–	Air Nova	St Johns	Newfoundland	Canada
S	1	2		1988	Feb-88	EI	MLG		NASA	82517										
E	211	5	24	1988	24-May-88	EI	Boeing	737	EURICE		Bae	–	–	None	–	–	TACA	New Orleans	Louisiana	USA
E	213	6	9	1988	9-Jun-88	EI	Bae	146	EURICE		Bae	–	–	None	–	–	Presidential Airlines	?	?	USA
E	216	11	2	1988	2-Nov-88	EI	IAI	Westwind	EURICE		NTSB	–	–	1059	–	–		Oak Grove	Pennsylvania	USA
E	199			1988		EI	Boeing	737	EURICE		CAA	–	–	Occrum 8804163H	–	–	Euroberlin	Frankfurt	—	Germany
E	226	2	3	1989	3-Feb-89	EI	McDonnell-Douglas	DC-9	EURICE		FAA	–	–	121	–	–	American Airlines	Dallas	Texas	USA
E	227	2	8	1989	8-Feb-89	EI	McDonnell-Douglas	DC-9	EURICE		FAA	–	–	121	–	–	American Airlines	Los Angeles	California	USA
E	234	3	24	1989	24-Mar-89	EI	Short	360	EURICE		ICAO	–	–	89/1167-0	–	–		?	?	USA
E	236	10	5	1989	5-Oct-89	EI	Tupolev	Tu-134	EURICE		Bae	–	–	None	–	–	Aeroflot	Moscow	—	USSR
E	237	11	17	1989	17-Nov-89	EI	Mitsubishi	MU-2	EURICE		FAA	–	–	135	–	–	International Flt Centre	Denver	Colorado	USA
E	239	12	13	1989	13-Dec-89	EI	Bae	146	EURICE		Bae	–	–	None	–	–	Air Nova	St Johns	Newfoundland	Canada
E	240	12	15	1989	15-Dec-89	EI	Fairchild	Metro	EURICE		FAA	–	–	135	–	–	Markair	Salt Lake City	Utah	USA

AIRCRAFT ICING ACCIDENT/INCIDENT DATABASE (Pg. 3/17)

ID code	ID #	Month	Day	Year	Date (dd-mmm-yy)	Code	A/C Type	A/C Type	Data base	Data base ref#	Data source 1	Data Source 2	Data Source 3	DatRef 1	DatRef 2	DatRef 3	Operator	Location	State	Country
E	226			1989		EI	McDonnell-Douglas	MD-80	EURICE		CAA	–	–	Occurum 8901111B	–	–	Paramount Airlines	?	?	?
E	236			1989		EI	Fokker	F27	EURICE		Bae	–	–	None	–	–		?	?	?
E	249	1	4	1990	4-Jan-90	EI	Boeing	727	EURICE		Bae	NLR	–	None	None	–	Northwest Airlines	Tallahassee	Florida	USA
E	250	1	8	1990	8-Jan-90	EI	McDonnell-Douglas	DC-9	EURICE		FAA	–	–	121	–	–	American Airlines	Portland	Oregon	USA
I	78	1	30	1990	30-Jan-90	EI	ER SIDDELEY-HS125 DOMINIE 1-600		ICAO	90/0017-0								COLUMBIA	UNITED STATES	
W	72	2	8	1990	8-Feb-90	EI	Bell 47J-2		TC (Walper)	A90O0083								Honey Harbour	Ontario	Canada
W	91	8	23	1990	23-Aug-90	EI	Socata TB-20		TC (Walper)	A90A0186								Makkovik	Newfoundland	Canada
W	70	11	8	1990	8-Nov-90	EI	Pilatus Britten-Norman BN-2B		TC (Walper)	A90A0253								Winter Bay	P E I	Canada
E	280	12	28	1990	28-Dec-90	EI	Boeing	727	EURICE		FAA	–	–	121	–	–	Federal Express	Indianapolis	Indiana	USA
E	243			1990		EI	Boeing	737	EURICE		CAA	–	–	Occurum 9000088B	–	–	Britannia Airways	Milan	—	Italy
E	244			1990		EI	Boeing	737	EURICE		CAA	–	–	Occurum 9000268X	–	–	British Airways	Ankara	—	Turkey
W	76	1	6	1991	6-Jan-91	EI	Cessna 208		TC (Walper)	A91C0003							North Management and Consultants	Thunder Bay	Ontario	Canada
E	269	1	7	1991	7-Jan-91	EI	Fokker	F27	EURICE		ICAO	–	–	91/0174-0	–	–		?	?	?
W	73	1	16	1991	16-Jan-91	EI	Lockheed 188 C		TC (Walper)	A91A0018							TPI International Airways	North Atlantic	North Atlantic	Canada
W	100	1	22	1991	22-Jan-91	EI	Cessna 150 M		TC (Walper)	A91O0044							Harbour Air Services	Toronto Island	Ontario	Canada
W	74	1	25	1991	25-Jan-91	EI	Piper PA-28-181		TC (Walper)	A91A0019							Tim McCandless Inc	St John's	Newfoundland	Canada
E	272	3	2	1991	2-Mar-91	EI	Bae	146	EURICE		ICAO	–	–	91/0053-0	–	–	Air Nova	?	?	USA
I	86	3	2	1991	2-Mar-91	EI	BAe-146		ICAO	91/0053-0							Air Nova	JACKSONVILLE	?	USA
W	75	5	19	1991	19-May-91	EI	Cessna 150 L		TC (Walper)	A91A0100								Wheaton Settlement	New Brunswick	Canada
W	103	7	14	1991	14-Jul-91	EI	Spectrum Beaver 560		TC (Walper)	A91P0133								Prince George	British Columbia	Canada
W	101	7	21	1991	21-Jul-91	EI	Piper PA-18-150		TC (Walper)	A91O0313								Dark Bay	Ontario	Canada
E	273	7	31	1991	31-Jul-91	EI	Bae	146	EURICE		CAA	–	–	Occurum ?	–	–	Air UK	?	?	?
E	274	8	9	1991	9-Aug-91	EI	Bae	146	EURICE		CAA	–	–	Occurum ?	–	–	TNT-Malmo	?	?	?
W	77	9	9	1991	9-Sep-91	EI	Cessna 140		TC (Walper)	A91C0201								Carrera	Saskatchewan	Canada
E	279	10	31	1991	31-Oct-91	EI	Piper	Navajo	EURICE		FAA	–	–	136	–	–	Martinaire	Oklahoma City	Oklahoma	USA
S	32	10		1991	Oct-91	EI	WDB		NASA	193073								UNZ	FO	
W	78	11	26	1991	26-Nov-91	EI	Blundell Wag-A-Bond Traveller		TC (Walper)	A91O0475								Paulgrave	Ontario	Canada
W	104	12	2	1991	2-Dec-91	EI	Piper PA-31T		TC (Walper)	A91Q0337							Avion Taxi	Lourdes-De-Blanc-Sablon	Quebec	Canada
W	96	12	21	1991	21-Dec-91	EI	Cessna 150 J		TC (Walper)	A91C0272								Thunder Bay	Ontario	Canada
W	80	12	24	1991	24-Dec-91	EI	Cessna Caravan		TC (Walper)	A91P0280								Piers Island	British Columbia	Canada
E	283	12	27	1991	27-Dec-91	EI	McDonnell-Douglas	MD-80	EURICE		ICAO	Bae	–	91/0610-0	None	–	Scandinavian Airlines	Stockholm	—	Sweden
E	263			1991		EI	Airbus	A320	EURICE		CAA	–	–	Occurum 9100736D	–	–	British Airways	Geneva	—	Switzerland
E	264			1991		EI	Fokker	F27	EURICE		CAA	–	–	Occurum 9100017C	–	–	Air UK	Hull	Humberside	UK
E	265			1991		EI	Fokker	F27	EURICE		CAA	Bae	–	Occurum 9100138X	None	–		?	?	?
E	266			1991		EI	McDonnell-Douglas	MD-80	EURICE		CAA	–	–	Occurum 9102566E	–	–	Airtours	?	?	?
E	290	1	26	1992	26-Jan-92	EI	Bae	146	EURICE		CAA	–	–	Occurum ?	–	–	Ansett	?	?	?
E	294	3	22	1992	22-Mar-92	EI	Bae	146	EURICE		Bae	–	–	None	–	–	Ansett	Nr Meekatharra	West Australia	Australia
E	298	6	22	1992	22-Jun-92	EI	Bae	146	EURICE		Bae	–	–	None	–	–		?	?	?
W	107	8	8	1992	8-Aug-92	EI	AAC AA-5		TC (Walper)	A92F0047								Piney Airport	United States	United States
E	267			1992		EI	Fokker	F100	EURICE		CAA	–	–	Occurum 9205480X	–	–	Air UK	Stansted	London	UK
W	84	1	2	1993	2-Jan-93	EI	Cessna 150 H		TC (Walper)	A93O0001								Stirling	Ontario	Canada
E	320	3	16	1993	16-Mar-93	EI	Boeing	737	EURICE		FAA	–	–	121	–	–	United Airlines	Birmingham	Alabama	USA
E	322	4	1	1993	1-Apr-93	EI	Fairchild	Metro	EURICE		ICAO	NTSB	–	93/0080-0	470	–		Blountville	Tennessee	USA
W	109	4	9	1993	9-Apr-93	EI	Cessna 150 L		TC (Walper)	A93A0081							Airborne Aviation Inc	Goose Bay	Newfoundland	Canada
E	323	4	11	1993	11-Apr-93	EI	Bae	ATP	EURICE		ICAO	NTSB	–	?	5039	–	Air Wisconsin	Oshkosh	Wisconsin	USA
E	333	6	10	1993	10-Jun-93	EI	Bae	Jetstream 41	EURICE		CAA	–	–	Occurum 9301640J	–	–	Loganair	?	?	?
W	118	6	24	1993	24-Jun-93	EI	Cessna 172		TC (Walper)	A93W0089								Carcross	Yukon	Canada
E	325	6	29	1993	29-Jun-93	EI	Bae	146	EURICE		CAA	Bae	–	Occurum ?	None	–	Empire Airlines	?	?	?
W	111	7	6	1993	6-Jul-93	EI	Taylorcraft BC-12D		TC (Walper)	A93C0111								La Ronge	Saskatchewan	Canada
W	108	8	3	1993	3-Aug-93	EI	Piper PA-28		TC (Walper)	A93A0167							Andre Belliveau	Moncton	New Brunswick	Canada
W	119	10	11	1993	11-Oct-93	EI	Cessna 172		TC (Walper)	A93W0172								Watson Lake	Yukon	Canada
W	120	10	16	1993	16-Oct-93	EI	Cessna 150 M		TC (Walper)	A93W0176							North Star Aviation	Lac La Biche	Alberta	Canada
E	328	11	2	1993	2-Nov-93	EI	Mitsubishi	MU-2	EURICE		Trans Can	–	–	A93P0227	–	–		Nr Vancouver	British Columbia	Canada
W	116	11	6	1993	6-Nov-93	EI	Cessna 172		TC (Walper)	A93O0367								Windsor	Ontario	Canada
W	85	11	24	1993	24-Nov-93	EI	Cessna 172 F		TC (Walper)	A93O0381								Amherstburg	Ontario	Canada
W	117	11	24	1993	24-Nov-93	EI	Cessna 150 L		TC (Walper)	A93Q0241							Aero-Club de Valcourt Inc	Orford	Quebec	Canada
W	83	11	28	1993	28-Nov-93	EI	Cessna 150 H		TC (Walper)	A93A0259								Debert	Nova Scotia	Canada
W	112	11	29	1993	29-Nov-93	EI	Lake LA-4-200		TC (Walper)	A93C0200								Winnipeg	Manitoba	Canada
W	121	12	10	1993	10-Dec-93	EI	Piper PA-34-200		TC (Walper)	A93W0206							Sky Wings Aviation Academy Ltd	Edmonton	Alberta	Canada
I	104	12	22	1993	22-Dec-93	EI	EROSPATIALE-SA 330J PUMA		ICAO	93/0399-0							GRYPHON A PLATFORM		UNITED KINGDOM	
W	110	12	24	1993	24-Dec-93	EI	Shorts SD3-30 Variant 300		TC (Walper)	A93A0278							Labrador Airways Ltd	Goose Bay	Newfoundland	Canada
E	308			1993		EI	Bae	ATP	EURICE		CAA	–	–	Occurum 9301105G	–	–	Air Wisconsin	Appleton	Wisconsin	USA
E	310			1993		EI	Bae	Jetstream 41	EURICE		CAA	–	–	Occurum 9301640J	–	–	Loganair	?	?	?
E	311			1993		EI	Bae	Jetstream 41	EURICE		CAA	–	–	Occurum 9301880G	–	–	Manx Airlines	?	?	?
W	87	1	16	1994	16-Jan-94	EI	Mooney M-20F		TC (Walper)	A94O0009								Jordan	Ontario	Canada
E	344	1	25	1994	25-Jan-94	EI	Bae	146	EURICE		Bae	–	–	None	–	–	TNT-PEAC	?	?	?
W	131	2	6	1994	6-Feb-94	EI	Cessna 150 M		TC (Walper)	A94Q0019							Aero Taxi	St-Hubert	Quebec	Canada
W	124	2	17	1994	17-Feb-94	EI	Cessna 172 K		TC (Walper)	A94C0022							James Bellis	Thompson	Manitoba	Canada
E	349	2	25	1994	25-Feb-94	EI	Vickers	Viscount	EURICE		ICAO	Bae	NLR	94/0015-0	None	None	British World Airlines	Uttoxeter	Staffordshire	UK
W	138	3	9	1994	9-Mar-94	EI	Harvard MK IV		TC (Walper)	A94W0027								Lacombe	Alberta	Canada
E	353	5	3	1994	3-May-94	EI	Saab	SF340	EURICE		ICAO	–	–	94/1055-0	–	–		?	?	USA
I	109	5	3	1994	3-May-94	EI	Saab 340		ICAO	94/1055-0								NASHVILLE	?	USA
W	123	5	16	1994	16-May-94	EI	Cessna 172		TC (Walper)	A94A0098							Grand Falls Aviation Service Ltd	Grand Falls	New Brunswick	Canada
W	133	5	28	1994	28-May-94	EI	Piper J-3C-65		TC (Walper)	A94Q0093								Lac Mist	Quebec	Canada
W	128	7	11	1994	11-Jul-94	EI	Cessna 150 L		TC (Walper)	A94P0136								Green Mountain	British Columbia	Canada
W	134	8	7	1994	7-Aug-94	EI	Cessna R182		TC (Walper)	A94Q0142							Aviation Duchesne	Mont-Louis	Quebec	Canada
E	356	9	8	1994	8-Sep-94	EI	Bae	146	EURICE		Bae	–	–	None	–	–		Nr Rome	—	Italy
W	127	9	11	1994	11-Sep-94	EI	DeHavilland DHC-3		TC (Walper)	A94O0246								Miska Lake	Ontario	Canada

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ID code	ID #	Month	Day	Year	Date (dd-mmm-yy)	Code	A/C Type	A/C Type	Data base	Data base ref#	Data source 1	Data Source 2	Data Source 3	DatRef 1	DatRef 2	DatRef 3	Operator	Location	State	Country
S	59	9		1994	Sep-94	EI	WDB		NASA	262477								TXKF	FO	
W	129	10	13	1994	13-Oct-94	EI	Mooney M-20C		TC (Walper)	A94P0239							Arthur Rutledge	Enderby VOR	British Columbia	Canada
I	110	10	16	1994	16-Oct-94	EI	CANADAIR-CL-600		ICAO	94/0373-0								NACOGDOCHES	UNITED STATES	
E	350	12	13	1994	13-Dec-94	EI	Bae	Jetstream 31	EURICE		Bae	–	–	None	–	–		Raleigh-Durham	North Carolina	USA
E	336			1994		EI	Boeing	737	EURICE		CAA	–	–	Occnum 9400368X	–	–	British Midland Airways	?	?	?
E	340			1994		EI	Bae	Jetstream 41	EURICE		CAA	–	–	Occnum 9405377D	–	–		Sydney	?	Australia
E	341			1994		EI	Bae	Jetstream 41	EURICE		CAA	–	–	Occnum 9401086X	–	–	Manx Airlines	Birmingham	Midlands	UK
E	347			1994		EI	Handley Page	Herald	EURICE		Bae	–	–	None	–	–		?	?	?
I	112	1	17	1995	17-Jan-95	EI	DeHavilland DHC-8-300		ICAO	95/2009-0								GRANDE PRAIRIE	CANADA	
W	144	2	25	1995	25-Feb-95	EI	Cessna 172		TC (Walper)	A95Q0048								Waskaganish	Quebec	Canada
W	145	3	30	1995	30-Mar-95	EI	Cessna 150 M		TC (Walper)	A95Q0086								Chambly	Quebec	Canada
E	366	5	4	1995	4-May-95	EI	McDonnell-Douglas	MD-80	EURICE		Bae	–	–	None	–	–		?	California	USA
W	148	5	5	1995	5-May-95	EI	Sorrell Hiperlight SNS-8		TC (Walper)	A95W0072								Strathmore	Alberta	Canada
W	146	5	24	1995	24-May-95	EI	Piper J-3C-65		TC (Walper)	A95Q0092								Lac Najoua	Quebec	Canada
W	140	7	16	1995	16-Jul-95	EI	Cessna 150 H		TC (Walper)	A95O0141								Kingston	Ontario	Canada
W	147	8	13	1995	13-Aug-95	EI	Norman Nordic VI		TC (Walper)	A95Q0159								St Camille de Bellechasse	Quebec	Canada
W	139	11	15	1995	15-Nov-95	EI	Cessna 172 N		TC (Walper)	A95C0248							Confederation College	Thunder Bay	Ontario	Canada
I	116	11	17	1995	17-Nov-95	EI	SAAB-340		ICAO	95/1164-0								CORSICANA	UNITED STATES	
W	141	11	28	1995	28-Nov-95	EI	Cessna 150 J		TC (Walper)	A95O0236								Manitouwaning	Ontario	Canada
I	117	12	19	1995	19-Dec-95	EI	CDONNELL-DOUGLAS-DC-9-30		ICAO	95/0487-0								ST.LOUIS	UNITED STATES	
E	367	12	29	1995	29-Dec-95	EI	Bae	146	EURICE		Bae	–	–	None	–	–		Edinburgh	Scotland	UK
E	360			1995		EI	Bae	146	EURICE		Bae	–	–	None	–	–		?	?	?
E	369			1995		EI	Fokker	F 100	EURICE		CAA	–	–	Occnum 9600094A	–	–	British Midland Airways	?	?	?
E	371			1995		EI	Bae	Jetstream 31	EURICE		CAA	–	–	Occnum 9600175A	–	–	British Aerospace	Warton	Lancashire	UK
E	373			1995		EI	Bae	Jetstream 41	EURICE		CAA	–	–	Occnum 9500898F	–	–		Portland	Dorset	uk
W	151	1	13	1996	13-Jan-96	EI	Cessna 180 B		TC (Walper)	A96C0003								Island Lake	Ontario	Canada
W	164	5	25	1996	25-May-96	EI	Cessna 150 F		TC (Walper)	A96W0096								Fort Simpson	N W T	Canada
E	395	5	29	1996	29-May-96	EI	Bae	146	EURICE		FBF	–	–	None	–	–	Air Wisconsin	Des Moines	Iowa	USA
W	152	8	14	1996	14-Aug-96	EI	Britten Norman BN-2A-27		TC (Walper)	A96C0157							Bolton Lake Air Services	Matheson Lake	Manitoba	Canada
W	158	9	22	1996	22-Sep-96	EI	Cessna 150 M		TC (Walper)	A96P0210								Pitt Meadows	British Columbia	Canada
W	161	10	27	1996	27-Oct-96	EI	Piper PA-28-140		TC (Walper)	A96Q0180								Les Cedres	Quebec	Canada
I	122	11	12	1996	12-Nov-96	EI	learjet25		ICAO	96/2923-0								CALGARY	CANADA	
E	400	1	8	1997	8-Jan-97	EI	Fairchild	Metro	EURICE		Flight	–	–	None	–	–	FNG Aviation	Nr Bullhead City	Arizona	USA
W	181	3	9	1997	9-Mar-97	EI	Cessna 152		TC (Walper)	A97Q0052							3008406 Canada Inc	Quebec	Quebec	Canada
W	182	3	28	1997	28-Mar-97	EI	Piper PA-28-180		TC (Walper)	A97Q0068								St-Bonaventure	Quebec	Canada
W	170	4	16	1997	16-Apr-97	EI	Slingsby Aviation PLC T 67C		TC (Walper)	A97C0082							Bombardier Inc.	Portage La Prairie	Manitoba	Canada
W	183	7	17	1997	17-Jul-97	EI	Cessna 175		TC (Walper)	A97Q0141								Baie-Des-Moutons	Quebec	Canada
W	169	10	4	1997	4-Oct-97	EI	Stinson 108		TC (Walper)	A97A0190								Halifax	Nova Scotia	Canada
W	179	10	4	1997	4-Oct-97	EI	Robinson R22 Beta		TC (Walper)	A97P0276							Tsayta Aviation Ltd	Smithers	British Columbia	Canada
W	172	10	10	1997	10-Oct-97	EI	Britten Norman BN-2A-27		TC (Walper)	A97C0201							Skyward Aviation Ltd	Thompson	Manitoba	Canada
W	189	1	16	1998	16-Jan-98	EI	Piper PA-28		TC (Walper)	A98C0004								St Andrews	Manitoba	Canada
W	186	2	23	1998	23-Feb-98	EI	Mecair Merlin GT		TC (Walper)	A98A0024								Chipman	New Brunswick	Canada
F	2	12	19	1946	19-Dec-46	GI	Douglas DC-3		FBF								Scottish Airways	Northolt	Middlesex	
F	3	1	25	1947	25-Jan-47	GI	Douglas DC-3		FBF								Spencer Airways	Croydon	Surrey	
F	4	11	19	1947	19-Nov-47	GI	Douglas DC-3		FBF								Willis Air Service	Richmond	Virginia	
F	7	10	19	1948	19-Oct-48	GI	Douglas DC-3		FBF								Columbia Air Cargo	Anchorage	Alaska	
F	8	12	18	1948	18-Dec-48	GI	Douglas DC-3		FBF								Reeve Aleutian	Anchorage	Alaska	
F	10	12	31	1948	31-Dec-48	GI	Douglas DC-3C		FBF								Air Cargo Express	Cleveland	Ohio	
F	11	1	2	1949	2-Jan-49	GI	Douglas DC-3C		FBF								Seattle Air Charter	Seattle	Washington	
F	17	3	27	1951	27-Mar-51	GI	Douglas DC-3		FBF								Air Transport Charter	Near Ringway Airport		
F	18	8	6	1951	6-Aug-51	GI	Douglas DC-3		FBF								TAA	Baffle Bay	Tasmania	
F	30	2	6	1958	6-Feb-58	GI	Airspeed Ambassador		FBF								BEA	Riem Airport		
F	40	11	20	1964	20-Nov-64	GI	Curtiss C46		FBF								Zantop Airways	Detroit	Michigan	
F	41	12	20	1965	20-Dec-65	GI	Grumman Gulfstream		FBF								Northern Consolidated Airlines	Bethel	Alaska	
F	43	11	19	1966	19-Nov-66	GI	Curtiss C46F		FBF									Kalkvik		
F	44	3	10	1967	10-Mar-67	GI	Fairchild F-27		FBF								West Coast Airlines	Klamath Falls	Oregon	
F	46	12	27	1968	27-Dec-68	GI	Douglas DC-9		FBF								Ozark Airlines	Sioux City	Iowa	
F	50	2	1	1969	1-Feb-69	GI	Beech D18S		FBF									Kansas City	Missouri	
F	51	2	25	1969	25-Feb-69	GI	Fokker F-28		FBF								LTU International Airways	Copenhagen		
F	52	3	26	1969	26-Mar-69	GI	Cessna 402		FBF									Chicago	Illinois	
F	54	12	4	1969	4-Dec-69	GI	Aero Commander AC1121B		FBF								Ehrenstroms Flyg	Stockholm		
E	476	2	9	1970	9-Feb-70	GI	de Havilland	Comet	EURICE		CAA WAAS	FBF	–	–	–	–	United Arab Airlines	Munich	Bavaria	Germany
F	57	2	9	1970	9-Feb-70	GI	Hawker Siddeley Comet 4C		FBF								UAA	Riem Airport		
I	2	2	9	1970	9-Feb-70	GI	Hawker Siddeley COMET 4C		ICAO	70/0060-0							UAA	Riem Airport		
E	478	3	22	1970	22-Mar-70	GI	Beech	18	EURICE		FBF	–	–	–	–	–		Binghampton	New York	USA
F	60	3	22	1970	22-Mar-70	GI	Beech C-45H		FBF									Binghamton	New York	
I	3	10	15	1970	15-Oct-70	GI	CONVAIR-28 Catalina		ICAO	70/1254-0								RHINELANDER		USA
E	474	3	18	1971	18-Mar-71	GI	Beech	18	EURICE		FBF	–	–	–	–	–		Chicago	Illinois	USA
F	61	3	18	1971	18-Mar-71	GI	Beech TC-45H		FBF									Chicago	Illinois	
E	470	2	16	1972	16-Feb-72	GI	Beech	18	EURICE		FBF	–	–	–	–	–		Jackson	Michigan	USA
F	65	2	16	1972	16-Feb-72	GI	Beech D18S		FBF									Jackson	Michigan	
E	480	10	31	1973	31-Oct-73	GI	Douglas	DC-3	EURICE		CAA WAAS	FBF	–	–	–	–	Superior Airways	Webenville	?	Canada
F	69	10	31	1973	31-Oct-73	GI	Douglas DC-3		FBF								Superior Airways	Webenville		
E	486	1	26	1974	26-Jan-74	GI	Fokker	F-28	EURICE		CAA WAAS	–	–	–	–	–	THY	Izmir	—	Turkey
F	71	1	26	1974	26-Jan-74	GI	Fokker F-28		FBF								THY	Cumaovasi		
E	482	1	14	1975	14-Jan-75	GI	Beech	18	EURICE		FAA	–	–	–	–	–		Evansville	Indiana	USA
F	74	1	14	1975	14-Jan-75	GI	Beech TC-45J		FBF									Evansville	Indiana	
F	76	2	21	1975	21-Feb-75	GI	Gates Learjet 25		FBF									Albuquerque	New Mexico	

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I	9	2	21	1975	21-Feb-75	GI	Lear-24		ICAO	75/1084-0								Albuquerque	New Mexico	USA
E	450	11	24	1975	24-Nov-75	GI	Beech	18	EURICE		FAA	–	–	–	–	–		Fort Wayne	Indiana	USA
F	78	11	24	1975	24-Nov-75	GI	Beech E18S		FBF									Fort Wayne	Indiana	
F	79	3	16	1976	16-Mar-76	GI	Beech 99		FBF									Wappingers Falls	New York	
E	444	11	29	1976	29-Nov-76	GI	de Havilland	Dove	EURICE		FAA	–	–	–	–	–		Albany	New York	USA
F	80	11	29	1976	29-Nov-76	GI	de Havilland DH-104		FBF									Albany	New York	
E	440	1	4	1977	4-Jan-77	GI	Boeing	737	EURICE		ICAO	CAA WAAS	–	12/77	–	–		Frankfurt	—	Germany
I	11	1	4	1977	4-Jan-77	GI	Boeing 737-100		ICAO	77/0428-0								Frankfurt	—	Germany
E	441	1	13	1977	13-Jan-77	GI	McDonnell-Douglas	DC-8	EURICE		NTSB	CAA	–	NTSB-AAR-78-7	Occnum 7700218D	–	Japan Airlines	Anchorage	Alaska	USA
F	81	1	13	1977	13-Jan-77	GI	Douglas DC-8		FBF								Japan Airlines	Anchorage	Alaska	
I	12	1	13	1977	13-Jan-77	GI	McDonnell-Douglas DC-8		ICAO	77/0002-0							Japan Airlines	Anchorage	Alaska	USA
I	13	1	14	1977	14-Jan-77	GI	BOEING-737-100		ICAO	77/0429-0								FRANKFURT/MAIN		GERMANY
E	433	1	28	1977	28-Jan-77	GI	Boeing	737	EURICE		CAA WAAS	–	–	–	–	–		Oslo	—	Norway
I	17	1	28	1977	28-Jan-77	GI	Boeing 737-100		ICAO	77/0409-0								Oslo	—	Norway
E	436	1	31	1977	31-Jan-77	GI	Chase	C122	EURICE		CAA	ICAO	–	Occnum 7705232C	–	–	Transnorthern Aviation	Anchorage	Alaska	USA
F	83	1	31	1977	31-Jan-77	GI	Chase YC122		FBF									Anchorage	Alaska	
I	18	1	31	1977	31-Jan-77	GI	Chase C122		ICAO	77/0086-0							Transnorthern Aviation	Anchorage	Alaska	USA
E	437	2	21	1977	21-Feb-77	GI	Lockheed	18	EURICE		CAA	–	–	Occnum 7705257J		–		Truckee	California	USA
I	19	2	21	1977	21-Feb-77	GI	Lockheed 18 Lodestar		ICAO	77/1080-0								Truckee	California	USA
E	429	2	20	1978	20-Feb-78	GI	Boeing	737	EURICE		CAA WAAS	–	–	–	–	–		Hannover	—	Germany
I	21	2	20	1978	20-Feb-78	GI	Boeing 737-100		ICAO	78/0156-0								Hannover	—	Germany
W	6	11	7	1978	7-Nov-78	GI	Cessna 310 N		TC (Walper)	A78W0114							Waskasoo Aviation Ltd	Swan Hills	Alberta	Canada
W	7	11	7	1978	7-Nov-78	GI	Beech 58		TC (Walper)	A78W0115							Angus Aviation	Swan Hills	Alberta	Canada
E	416	11	27	1978	27-Nov-78	GI	McDonnell-Douglas	DC-9	EURICE		CAA WAAS	–	–	–	–	–	Trans World Airlines	Newark	New Jersey	USA
F	87	11	27	1978	27-Nov-78	GI	Douglas DC-9		FBF								Trans World Airways	Newark	New Jersey	
I	24	11	27	1978	27-Nov-78	GI	McDonnell-Douglas DC-9		ICAO	78/0470-0							Trans World Airlines	Newark	New Jersey	USA
E	413	12	20	1978	20-Dec-78	GI	Lear	Learjet	EURICE		CAA	CAA WAAS	–	Occnum 7805589G	–	–		Minneapolis	Minnesota	USA
E	406	2	12	1979	12-Feb-79	GI	Nord	262	EURICE		FBF	–	–	None	–	–	Allegheny Airlines	Clarksburg	West Virginia	USA
F	84	2	12	1979	12-Feb-79	GI	Frakes Mohawk 298		FBF								USAir	Clarksburg	West Virginia	
I	29	2	12	1979	12-Feb-79	GI	NORD 262		ICAO	79/0072-0							Allegheny Airlines	Clarksburg	West Virginia	USA
E	402	11	23	1979	23-Nov-79	GI	Scottish Aviation	Twin Pioneer	EURICE		FBF	CAA	–	None	Occnum 7905438B	–		Anchorage	Alaska	USA
F	88	11	23	1979	23-Nov-79	GI	Scottish Aviation Twin Pionee		FBF									Anchorage	Alaska	
I	31	11	23	1979	23-Nov-79	GI	Scottish Aviation		ICAO	79/0452-0								Anchorage	Alaska	USA
E	8	2	16	1980	16-Feb-80	GI	Bristol	Britannia	EURICE		Bas	ICAO	–	None	80/0032-0	–	Redcoat Air Cargo	Billerica	Massachusetts	USA
F	89	2	16	1980	16-Feb-80	GI	Bristol Britannia 253F		FBF								Redcoat Air Cargo	Billerica	Massachusetts	
E	5			1980		GI	Boeing	737	EURICE		CAA	–	–	Occnum 8004825G	–	–	Britannia Airways	Hannover	–	Germany
E	29	3	11	1981	11-Mar-81	GI	Cessna	401	EURICE		ICAO	NTSB	–	81/1059-0	3-0988	–		Bloomsburg	Pennsylvania	USA
E	34	12	21	1981	21-Dec-81	GI	Boeing	737	EURICE		ICAO	–	–	81/0377-0	–	–		?	?	?
I	38	12	21	1981	21-Dec-81	GI	Boeing 737-200		ICAO	81/0377-0								Hannover		Germany
E	17			1981		GI	Boeing	737	EURICE		CAA	–	–	Occnum 8104186C	–	–	Lufthansa	?	?	?
E	18			1981		GI	Boeing	737	EURICE		CAA	–	–	Occnum 8100986F	–	–	Britannia Airways	Geneva	?	Switzerland
E	19			1981		GI	Boeing	737	EURICE		CAA	–	–	Occnum ?	–	–	British Airways	London		UK
E	20			1981		GI	Boeing	737	EURICE		CAA	–	–	Occnum 8100551B	–	–	Britannia Airways	Birmingham		UK
E	23			1981		GI	McDonnell-Douglas	DC-9	EURICE		CAA	–	–	Occnum 8104181X	–	–	Finnair	?	?	?
E	46	1	13	1982	13-Jan-82	GI	Boeing	737	EURICE		ICAO	–	–	82/0102-0	–	–		?	?	Germany
E	47	1	13	1982	13-Jan-82	GI	Boeing	737	EURICE		ICAO	FAA	NTSB	82/0001-0	121	3375	Air Florida	Washington	Dist of Columbia	USA
F	106	1	13	1982	13-Jan-82	GI	Boeing 737-222		FBF								Air Florida	Washington	D. C.	
I	40	1	13	1982	13-Jan-82	GI	Boeing 737		ICAO	82/0102-0								MUENCHEN		Germany
I	39	1	13	1982	13-Jan-82	GI	Boeing 737-200		ICAO	82/0001-0							Air Florida	Washington	D. C.	
E	50	1	14	1982	14-Jan-82	GI	Boeing	737	EURICE		ICAO	–	–	82/0101-0	–	–		?	?	Germany
I	41	1	14	1982	14-Jan-82	GI	BOEING-737-200		ICAO	82/0101-0								NUERNBERG		GERMANY
E	59	5	7	1982	7-May-82	GI	Douglas	DC-3	EURICE		ICAO	–	–	82/2022-0	–	–		?	?	Canada
I	42	5	7	1982	7-May-82	GI	Douglas DC-3		ICAO	82/2022-0								CALGARY INTL A/P	?	Canada
W	31	11	17	1982	17-Nov-82	GI	Piper PA-28		TC (Walper)	A82W0086								Vermilion	Alberta	Canada
E	40			1982		GI	Boeing	737	EURICE		CAA	–	–	Occnum 8200374B	–	–	Lufthansa	?	?	?
E	41			1982		GI	Boeing	737	EURICE		CAA	–	–	Occnum 8200375X	–	–		?	?	?
W	46	1	6	1984	6-Jan-84	GI	Ultralight Lazair		TC (Walper)	A84W5001								Montney	British Columbia	Canada
F	107	1	13	1984	13-Jan-84	GI	Fokker F-27		FBF								Pilgrim Airlines	New York	New York	
I	49	1	13	1984	13-Jan-84	GI	Fokker F-27		ICAO	84/0087-0							Pilgrim Airlines	New York	New York	USA
E	120	12	16	1984	16-Dec-84	GI	Piper	Aerostar	EURICE		ICAO	NTSB	FAA	84/0051-0	2812	091		Mammoth Lakes	California	USA
E	87			1984		GI	Avro	748	EURICE		CAA	–	–	Occnum 8403831A	–	–	British Airways	Stornoway	Scotland	UK
E	89			1984		GI	Avro	748	EURICE		CAA	–	–	Occnum 8400046E	–	–	Dan-Air	–	Irish Sea	UK
E	134	2	6	1985	6-Feb-85	GI	Douglas	DC-3	EURICE		ICAO	FAA	CAA	85/0056-0	121	Occnum 8501744B	Bowman Aviation	Charlotte	North Carolina	USA
E	135	2	5	1985	5-Feb-85	GI	McDonnell-Douglas	DC-9	EURICE		ICAO	NTSB	FAA	85/1066-0	2682	121	Airborne Express	Philadelphia	Pennsylvania	USA
F	109	2	6	1985	6-Feb-85	GI	Douglas DC-3		FBF								BO-S-AIRE Airlines	Charlotte	North Carolina	
F	110	2	5	1985	5-Feb-85	GI	Douglas DC-9-15		FBF								Airborne Express	Philadelphia	Pennsylvania	
I	54	2	6	1985	6-Feb-85	GI	Douglas DC-3		ICAO	85/0056-0							Bowman Aviation	Charlotte	North Carolina	USA
I	55	2	5	1985	5-Feb-85	GI	McDonnell-Douglas DC-9-10		ICAO	85/1066-0							Airborne Express	Philadelphia	Pennsylvania	USA
F	111	3	12	1985	12-Mar-85	GI	de Havilland DHC-6		FBF								Sea Airmotive	Barter Island	Alaska	
E	145	4	2	1985	2-Apr-85	GI	Cessna	Golden Eagle	EURICE		NTSB	FAA	–	842	091	–		Binghamton	New York	USA
E	150	12	12	1985	12-Dec-85	GI	Douglas	DC-8	EURICE		ICAO	FAA	Bas	85/2065-0	121	None	Arrow Air	Gander	Newfoundland	Canada
F	112	12	12	1985	12-Dec-85	GI	Douglas DC-8		FBF								Arrow Air Gander	Newfoundland		
I	59	12	12	1985	12-Dec-85	GI	CDONNELL-DOUGLAS-DC-8-63		ICAO	85/2065-0								GANDER		CANADA
E	151	12	15	1985	15-Dec-85	GI	Douglas	DC-3	EURICE		ICAO	FAA	Bas	85/0414-0	091	None		Dillingham	Alaska	USA
F	113	12	15	1985	15-Dec-85	GI	Douglas DC-3		FBF									Dillingham	Alaska	
I	60	12	15	1985	15-Dec-85	GI	Douglas DC-3		ICAO	85/0414-0								Dillingham	Alaska	
E	152	12	24	1985	24-Dec-85	GI	Cessna	401	EURICE		FAA	–	–	091	–	–	Mountain Air Cargo	Grand Rapids	Michigan	USA
I	62	1	10	1986	10-Jan-86	GI	Fokker F-27		ICAO	86/0379-0								FRANKFURT	?	Germany

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ID code	ID #	Month	Day	Year	Date (dd-mmm-yy)	Code	A/C Type	A/C Type	Data base	Data base ref#	Data source 1	Data Source 2	Data Source 3	DatRef 1	DatRef 2	DatRef 3	Operator	Location	State	Country
F	117	12	15	1986	15-Dec-86	GI	Antonov An-24		FSF								CAAC	Near Lanzhou		
E	160			1986		GI	Bae	Jetstream 31	EURICE		CAA	–	–	Occurrum 8610889G	–	–		Amsterdam	–	Netherlands
E	179	1	6	1987	6-Jan-87	GI	Sud Aviation	Caravelle	EURICE		ICAO	Bae	–	87/0006-0	None	–	Transwede	Stockholm	—	Sweden
F	118	1	6	1987	6-Jan-87	GI	Aerospatiale Caravelle 12		FSF									Transwede		
I	64	1	6	1987	6-Jan-87	GI	Aerospatiale Caravelle 12		ICAO	87/0006-0							Transwede	Stockholm	—	Sweden
E	181	1	22	1987	22-Jan-87	GI	Saab	SF340	EURICE		FAA	–	–	091	–	–		Bloomington	Indiana	USA
E	190	11	15	1987	15-Nov-87	GI	McDonnell-Douglas	DC-9	EURICE		ICAO	NTSB	Bae	87/0258-0	1266	None	Continental Airlines	Denver	Colorado	USA
F	122	11	15	1987	15-Nov-87	GI	McDonnell Douglas DC-9-14		FSF								Continental Airlines Denver		Colorado	
I	67	11	15	1987	15-Nov-87	GI	McDonnell Douglas DC-9-10		ICAO	87/0258-0							Continental Airlines	Denver	Colorado	USA
E	185	12	19	1987	19-Dec-87	GI	Cessna	Caravan	EURICE		ICAO	NTSB	–	87/1008-0	2212	–	Hermens Air	Bethel	Alaska	USA
E	203	1	10	1988	10-Jan-88	GI	NAMC	YS-11	EURICE		ICAO	Bae	–	88/0002-0	None	–	Toa Domestic Airlines	Honshu	—	Japan
F	125	1	10	1988	10-Jan-88	GI	NAMC YS-11		FSF								Toa Domestic	Honshu		
I	60	1	10	1988	10-Jan-88	GI	NAMC YS-11A		ICAO	88/0002-0							Toa Domestic Airlines	Honshu	—	Japan
E	204	1	18	1988	18-Jan-88	GI	Cessna	401	EURICE		ICAO	NTSB	FAA	88/0027-0	41	135	South Aero Services	Albuquerque	New Mexico	USA
E	210	3	3	1988	3-Mar-88	GI	Beech	18	EURICE		ICAO	NTSB	FAA	88/0102-0	1774	135	Midwest Executive	Vienna	Missouri	USA
E	216	11	24	1988	24-Nov-88	GI	Cessna	401	EURICE		ICAO	–	–	88/0406-0	–	–		?	?	Sweden
E	221	12	28	1988	28-Dec-88	GI	Fokker	F27	EURICE		FAA	–	–	121	–	–	Air Wisconsin	Chicago	Illinois	USA
E	226	2	10	1989	10-Feb-89	GI	de Havilland Canada	Otter	EURICE		ICAO	NTSB	–	89/1001-0	475	–		Fairbanks	Alaska	USA
F	126	3	3	1989	3-Mar-89	GI	Fokker F-28		FSF								Air Ontario	Dryden	Ontario	
E	231	3	9	1989	9-Mar-89	GI	Beech	18	EURICE		ICAO	NTSB	–	89/0087-0	870	–	Ajax Leasing Inc	Covington	Kentucky	USA
E	232	3	10	1989	10-Mar-89	GI	Fokker	F28	EURICE		Bae	–	–	None	–	–	Air Ontario	Dryden	Ontario	Canada
W	80	3	10	1989	10-Mar-89	GI	Fokker F-28 MK 1000		TC (Walper)	A89C0048							Air Ontario	Dryden	Ontario	Canada
W	66	11	8	1989	8-Nov-89	GI	Cessna 404		TC (Walper)	A89C0214							Skyward Aviation Ltd	Thompson	Manitoba	Canada
E	238	11	25	1989	25-Nov-89	GI	Fokker	F28	EURICE		CAA	–	–	Occurrum 8904721D	–	–	Korean Air	Kimpo	—	Korea
F	130	11	25	1989	25-Nov-89	GI	Fokker F-28		FSF								Korean Air	Kimpo		
I	78	11	25	1989	25-Nov-89	GI	Fokker F28		ICAO	89/0425-0							Korean Air	Kimpo	—	Korea
E	251	1	29	1990	29-Jan-90	GI	Cessna	Caravan	EURICE		ICAO	NTSB	FAA	90/1119-0	1121	135	Wiggins Airways	Plattsburgh	New York	USA
E	258	10	17	1990	17-Oct-90	GI	Cessna	Golden Eagle	EURICE		NTSB	FAA	–	1038	091	–		Jackson Hole	Wyoming	USA
E	271	2	17	1991	17-Feb-91	GI	McDonnell-Douglas	DC-9	EURICE		ICAO	NTSB	FAA	91/0048-0	153	121	Ryan International A/L	Cleveland	Ohio	USA
F	134	2	17	1991	17-Feb-91	GI	Douglas DC-9		FSF								Ryan International Airlines	Cleveland	Ohio	
I	85	2	17	1991	17-Feb-91	GI	Douglas DC-9		ICAO	91/0049-0							Ryan International Airlines	Cleveland	Ohio	
W	102	2	17	1991	17-Feb-91	GI	Piper PA-11		TC (Walper)	A91P0024								Hudson Hope	British Columbia	Canada
F	136	12	27	1991	27-Dec-91	GI	McDonnell Douglas MD-81		FSF								Scandinavian Airlines System	Stockholm		
I	80	12	27	1991	27-Dec-91	GI	McDonnell-Douglas MD-80		ICAO	91/0610-0							Scandinavian Airlines	Stockholm	—	Sweden
E	280	1	4	1992	4-Jan-92	GI	Cessna	Golden Eagle	EURICE		ICAO	NTSB	FAA	92/1070-0	3	091		Steamboat Springs	Colorado	USA
E	295	3	22	1992	22-Mar-92	GI	Fokker	F28	EURICE		ICAO	NTSB	Bae	92/0229-0	1046	None	US Air	New York	New York	USA
F	138	3	22	1992	22-Mar-92	GI	Fokker F-28		FSF								USAir	Flushing	New York	
I	84	3	22	1992	22-Mar-92	GI	Fokker F-28 MK 4000		ICAO	92/0229-0							US Air	New York	New York	USA
E	318	2	20	1993	20-Feb-93	GI	Cessna	401	EURICE		NTSB	FAA	–	348	135	–	Ryan Air Services	Nome	Alaska	USA
S	44	2		1993	Feb-93	GI	MLG		NASA	234440								IAD	VA	
E	319	3	5	1993	5-Mar-93	GI	Fokker	F100	EURICE		Bae	FAA	–	None	?	–	Palair Macedonian A/L	Skopje	—	Macedonia
F	139	3	5	1993	5-Mar-93	GI	Fokker F-100		FSF								Palair Macedonian Airlines	Skopje		
I	98	3	5	1993	5-Mar-93	GI	Fokker 100		ICAO	93/0204-0							Palair Macedonian Airlines	Skopje		
E	330	11	10	1993	10-Nov-93	GI	Avro	748	EURICE		Trans Can	Bae	–	A93?	None	–	Air Manitoba	Sandy Lake	?	Canada
S	54	1		1994	Jan-94	GI	MLG		NASA	261422								BNA	TN	
E	352	3	18	1994	18-Mar-94	GI	Piper	Aerostar	EURICE		NTSB	FAA	–	489	091	–		Limerick	Pennsylvania	USA
E	339			1994		GI	Fokker	F100	EURICE		CAA	–	–	Occurrum 9401270J	–	–	Air UK	Gatwick	London	UK
E	378	1	18	1995	18-Jan-95	GI	Cessna	Caravan	EURICE		NTSB	–	–	352	–	–	Martinaire	Lubbock	Texas	USA
S	64	1		1995	Jan-95	GI	LRG		NASA	294262								ORD	IL	
E	376			1995		GI	Bae	748	EURICE		Bae	–	–	None	–	–	RAF	?	?	Norway
W	167	3	10	1987	10-Mar-87	GI	Beech 1900		TC (Walper)	A87A0088							Central Mountain Air Services Ltd	Fredericton	New Brunswick	Canada
I	124	3	14	1987	14-Mar-87	GI	Fokker F-28 MK 1000		ICAO	97/2236-0							Time Air Ltd	Toronto Int'l	Ontario	Canada
W	177	3	14	1987	14-Mar-87	GI	Fokker F-28 MK 1000		TC (Walper)	A87O0048							Time Air Ltd	Toronto Int'l	Ontario	Canada
W	187	1	13	1988	13-Jan-88	GI	Beech 1900		TC (Walper)	A88P0011							Central Mountain Air Services Ltd	Cranbrook	British Columbia	Canada
I	15	1	25	1977	25-Jan-77	RI	BOEING-707-300		ICAO	77/0014-1								NEW YORK/JFK		UNITED STATES
I	16	1	25	1977	25-Jan-77	RI	BOEING-727-100		ICAO	77/0014-2								NEW YORK/JFK		UNITED STATES
W	190	3	17	1977	17-Mar-77	RI	Cessna 310 Q		TC (Icing)	A77A0009							Air Bathurst Ltd	Bathurst Airport	New Brunswick	Canada
W	192	3	25	1977	25-Mar-77	RI	Cessna 180 A		TC (Icing)	A77C0026								Red Lake	Ontario	Canada
W	198	6	14	1977	14-Jun-77	RI	DeHavilland DHC-6-200		TC (Icing)	A77C0077							Bradley Air Services Ltd	Cornwallis Island	N W T	Canada
W	209	12	11	1977	11-Dec-77	RI	Piper PA-28		TC (Icing)	A77O0123							St. Catharines Flying Club	St. Catharines	Ontario	Canada
W	230	12	24	1977	24-Dec-77	RI	Cessna 172 M		TC (Icing)	A77W4126								Edmonton Muni AP	Alberta	Canada
I	27	12	11	1978	11-Dec-78	RI	LEARJET-24		ICAO	78/0451-0								MUSCATINE		UNITED STATES
I	29	1	22	1979	22-Jan-79	RI	LOCKHEED-1329 JETSTAR		ICAO	79/0108-0								CONCORD		UNITED STATES
I	44	2	8	1983	8-Feb-83	RI	LEARJET-24		ICAO	83/1003-0										UNITED STATES
I	45	2	25	1983	25-Feb-83	RI	CDONNELL-DOUGLAS-DC-9		ICAO	83/0056-0								NUIQSUT		UNITED STATES
I	46	3	8	1983	8-Mar-83	RI	CONVAIR-CV 580		ICAO	83/2013-0								LG-4		CANADA
I	48	4	19	1983	19-Apr-83	RI	ER SIDDELEY-HS125 DOMINIE 1-400		ICAO	83/2024-0								GASPE AIRPORT	Quebec	ADA
I	57	11	21	1985	21-Nov-85	RI	ORTH AMERICAN-SABRELINER		ICAO	85/1076-0								DENVER		UNITED STATES
I	58	11	29	1985	29-Nov-85	RI	ISRAEL-IAI-1124		ICAO	85/0388-0								WORCESTER		UNITED STATES
I	61	1	2	1986	2-Jan-86	RI	CDONNELL-DOUGLAS-DC-10-10		ICAO	86/1068-0								DETROIT		UNITED STATES
I	70	2	2	1988	2-Feb-88	RI	CONVAIR-CV 580		ICAO	88/0036-0								DURANGO		UNITED STATES
I	72	11	17	1988	17-Nov-88	RI	LEARJET-25		ICAO	88/0414-0								BEND		UNITED STATES
I	75	2	15	1989	15-Feb-89	RI	ASSAULT-BREGUET-FALCON 20		ICAO	89/0075-0								BINGHAMTON		UNITED STATES
I	82	1	7	1991	7-Jan-91	RI	BOEING-737-300		ICAO	91/1036-0								KANSAS CITY		UNITED STATES
I	84	2	14	1991	14-Feb-91	RI	UMMAN-G1159 GULFSTREAM II		ICAO	91/0008-0								CLEVELAND		UNITED STATES
I	93	3	3	1992	3-Mar-92	RI	CDONNELL-DOUGLAS-DC-9		ICAO	92/0042-0								SELAWIK		UNITED STATES
I	101	10	8	1993	8-Oct-93	RI	ELL-DOUGLAS-DC-4 SKYMASTER/C-54		ICAO	93/1047-0								POINT LAY		UNITED STATES
I	103	12	21	1993	21-Dec-93	RI	ONNELL-DOUGLAS-MD80 SERIES		ICAO	93/0243-0								LEIPZIG/HALLE		GERMANY

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S	51	12		1980	Dec-80	RI	MLG		NASA	292538								DEN	CO	
I	105	1	3	1994	3-Jan-94	RI	EARINGEN-SA226 TC METRO II		ICAO	94/0013-0								RICHMOND HEIGHT	UNITED STATES	
W	126	1	23	1994	23-Jan-94	RI	Boeing 767-375		TC (Walper)	A94O0017							Canadian Airlines International	Toronto Int'l	Ontario	Canada
I	109	1	31	1994	31-Jan-94	RI	NELL-DOUGLAS-DC-3 DAKOTA/C-47		ICAO	94/0019-0								ANDERSON	UNITED STATES	
W	132	2	8	1994	8-Feb-94	RI	Cessna 150 M		TC (Walper)	A94Q0020								St-Jerome	Quebec	Canada
W	88	12	20	1995	20-Dec-95	RI	Boeing 737-200		TC (Walper)	A95W0234							Canadian Airlines International	Calgary Int'l	Alberta	Canada
W	155	2	7	1996	7-Feb-96	RI	Boeing 737		TC (Walper)	A96P0010							Tessa	Kelowna	British Columbia	Canada
W	167	11	21	1996	21-Nov-96	RI	Piper PA-31		TC (Walper)	A96P0264							North Vancouver Airline Ltd	Cranbrook	British Columbia	Canada
W	194	4	5	1997	5-Apr-97	RI	Cessna 185		TC (Icing)	A77C0036							Tomahawk Airways	Spirit Lake	Ontario	Canada
I	125	10	21	1997	21-Oct-97	RI	Boeing 727		ICAO	97/2674-0							Kelowna Flightcraft	Winnipeg	Manitoba	Canada
W	173	10	21	1997	21-Oct-97	RI	Boeing 727		TC (Walper)	A97C0213							Kelowna Flightcraft	Winnipeg	Manitoba	Canada
W	188	1	18	1998	18-Jan-98	RI	Boeing 737-200		TC (Walper)	A98P0021							Canadian Airlines International	Terrace	British Columbia	Canada
F	1	9	24	1946	24-Sep-46	BI	Douglas DC-3		FBF								A. R. Lyle	Point Barrow	Alaska	
F	5	12	21	1947	21-Dec-47	BI	Douglas DC-3C		FBF								Seattle Air Charter	North Platte	Nebraska	
F	8	3	2	1948	2-Mar-48	BI	Douglas DC-3		FBF								Meteor	Newark	New Jersey	
F	9	12	19	1948	19-Dec-48	BI	Douglas DC-4		FBF								Alaska	Minneapolis	Minnesota	
F	12	1	6	1949	6-Jan-49	BI	Douglas DC-3C		FBF								Coastal Cargo	Brandywine	Maryland	
F	13	3	2	1949	2-Mar-49	BI	Douglas C-54B		FBF								Trans World Airways	Gander	Newfoundland	
F	14	10	8	1949	8-Oct-49	BI	Curtiss C46F		FBF								Slick Airways	Cheyenne	Wyoming	
F	15	2	16	1950	16-Feb-50	BI	Douglas DC-3		FBF								Eastern Airlines	Lexington	Kentucky	
F	16	2	23	1951	23-Feb-51	BI	Curtiss C46E		FBF								Slick Airways	Newhall	California	
F	18	11	1	1951	1-Nov-51	BI	Curtiss C46F		FBF								Flying Tiger	Cleveland	Ohio	
F	20	1	7	1953	7-Jan-53	BI	Curtiss C46F		FBF								Associated Air Transportation	Fish Haven	Idaho	
F	21	1	20	1954	20-Jan-54	BI	Douglas DC-3A		FBF								Zantop Airways	Near Kansas City	Missouri	
F	22	2	5	1954	5-Feb-54	BI	Curtiss C46F		FBF								Flying Tiger	Romulus	Michigan	
F	23	2	26	1954	26-Feb-54	BI	Convair 240		FBF								Western	Near Wright	Wyoming	
F	24	12	29	1955	29-Dec-55	BI	Lockheed 18 (Lodestar)		FBF								Gulf Refining	Near Londonderry	Ohio	
F	25	1	17	1956	17-Jan-56	BI	Douglas DC-3C		FBF								Quebecair	Oraway	Labrador	
F	26	11	7	1956	7-Nov-56	BI	de Havilland Heron II		FBF								Braathens SAFE Hommelfjell	Tolga		
F	27	10	4	1957	4-Oct-57	BI	Douglas DC-3		FBF								Eldorado	Fort McMurray	Alberta	
F	28	11	17	1957	17-Nov-57	BI	Vickers Viscount 802		FBF								BEAC	Near Copenhagen		
F	29	12	6	1957	6-Dec-57	BI	L-1049G		FBF								Air France	Orly Airport		
F	31	4	6	1958	6-Apr-58	BI	Vickers Viscount 745		FBF								Capital Airlines	Freeland	Michigan	
F	32	12	4	1958	4-Dec-58	BI	Sud-est SE 161 (Languedoc)		FBF								AVIACO	Guadarrama Mountains		
F	33	2	1	1959	1-Feb-59	BI	Douglas DC-3		FBF								General Airways	Kerrville	Texas	
F	34	1	18	1960	18-Jan-60	BI	Vickers Viscount		FBF								Capital Airlines	Charles City	Virginia	
F	35	2	13	1960	13-Feb-60	BI	Curtiss C46		FBF								Associated Air Transportation	McGuire Air Force Base	New Jersey	
F	36	1	29	1963	29-Jan-63	BI	Vickers Viscount 810		FBF								Continental Airlines	Kansas City	Missouri	
F	37	12	21	1963	21-Dec-63	BI	Convair 440		FBF									Midland	Texas	
F	38	3	8	1964	8-Mar-64	BI	Douglas DC-3A		FBF								Snow Valley Ski	Chicago	Illinois	
F	39	3	10	1964	10-Mar-64	BI	Douglas DC-4		FBF								Slick Airways	Boston	Massachusetts	
F	45	10	26	1967	26-Oct-67	BI	Gates Learjet 23		FBF								Executive Jet Aviation	Muskegon	Michigan	
F	46	1	15	1968	15-Jan-68	BI	Douglas DC-3		FBF								UAA		Zifta	
F	48	12	18	1968	18-Dec-68	BI	Beech G18S		FBF									Kenai	Alaska	
F	53	10	3	1969	3-Oct-69	BI	Beech 65-B80		FBF									Denver	Colorado	
F	55	12	5	1969	5-Dec-69	BI	Lockheed 18 (Lodestar)		FBF									Albuquerque	New Mexico	
E	480	1	22	1970	22-Jan-70	BI	Rockwell	Commander 500	EURICE		FBF	–	–	–	–	–		Aspen	Colorado	USA
F	56	1	22	1970	22-Jan-70	BI	Aero Commander 680 V		FBF									Aspen	Colorado	
E	479	2	14	1970	14-Feb-70	BI	Beech	18	EURICE		FBF	–	–	–	–	–		Kansas City	Kansas	USA
F	58	2	14	1970	14-Feb-70	BI	Beech E18S		FBF									Kansas City	Kansas	
E	477	12	23	1970	23-Dec-70	BI	Beech	18	EURICE		FBF	–	–	–	–	–		Lansing	Michigan	USA
F	60	12	23	1970	23-Dec-70	BI	Beech H18S		FBF									Lansing	Michigan	
E	473	12	8	1971	8-Dec-71	BI	Beech	18	EURICE		FBF	–	–	–	–	–		Grand Island	Nebraska	USA
F	62	12	8	1971	8-Dec-71	BI	Beech Volpar		FBF									Grand Island	Nebraska	
E	472	12	18	1971	18-Dec-71	BI	Beech	Queen Air	EURICE		FBF	–	–	–	–	–		McCall	Idaho	USA
F	63	12	18	1971	18-Dec-71	BI	Beech 65-B80		FBF									McCall	Idaho	
E	467	1	30	1972	30-Jan-72	BI	Douglas	DC-3	EURICE		CAA WAAS	FBF	–	–	–	–	Douglas Inc.	Boyne Falls	Michigan	USA
E	466	3	15	1972	15-Mar-72	BI	?	?	EURICE		FBF	–	–	–	–	–		Brook Park	Ohio	USA
F	66	3	16	1972	16-Mar-72	BI	Aircraft not identified		FBF									Brook Park	Ohio	
E	464	12	8	1972	8-Dec-72	BI	Douglas	DC-3	EURICE		CAA WAAS	FBF	–	–	–	–	Superior Airways	?	?	Canada
F	67	12	8	1972	8-Dec-72	BI	Douglas DC-3		FBF								Superior Airways			
E	462	3	3	1973	3-Mar-73	BI	Ilyushin	IL-18	EURICE		CAA WAAS	FBF	–	–	–	–	Balkan-Bulgarian A/L	Moscow	—	USSR
F	68	3	3	1973	3-Mar-73	BI	Ilyushin Il-18		FBF								Balkan-Bulgarian Airlines	Moscow		
E	458	1	6	1974	6-Jan-74	BI	Beech	99	EURICE		FBF	–	–	–	–	–		Johnstown	Pennsylvania	USA
F	70	1	6	1974	6-Jan-74	BI	Beech 99A		FBF									Johnstown	Pennsylvania	
I	8	5	6	1974	6-May-74	BI	CDONNELL-DOUGLAS DC-8		ICAO	74/0120-0							NUERNBERG		GERMANY	
E	454	12	1	1974	1-Dec-74	BI	Boeing	727	EURICE		CAA WAAS	–	–	–	–	–	Northwest Airlines	Nr Stoney Brook	New York	USA
F	72	12	1	1974	1-Dec-74	BI	Boeing 727		FBF								Northwest Airlines	Near Stony Brook	New York	
E	453	1	2	1975	2-Jan-75	BI	Beech	18	EURICE		FAA	–	–	–	–	–		Rockford	Illinois	USA
F	73	1	2	1975	2-Jan-75	BI	Beech E18S		FBF									Rockford	Illinois	
I	7	1	16	1975	16-Jan-75	BI	Curtiss C-46		ICAO	75/0121-0							Aerovias Las Minas	Nr La Paz	—	Bolivia
E	451	1	31	1975	31-Jan-75	BI	Cessna	402	EURICE		FAA	–	–	–	–	–		Dodge City	Kansas	USA
F	75	1	31	1975	31-Jan-75	BI	Cessna 402B		FBF									Dodge City	Kansas	
I	9	2	1	1975	1-Feb-75	BI	HEED-VEGA 37 VENTURA B34/PV1		ICAO	75/1086-0								EGG HARBOR	UNITED STATES	
E	449	2	21	1976	21-Feb-76	BI	Lear	Learjet	EURICE		CAA WAAS	–	–	–	–	–		Albuquerque	New Mexico	USA
F	77	3	12	1976	12-Mar-76	BI	Beech 95-C55		FBF									Gaylord	Michigan	
E	446	3	16	1976	16-Mar-76	BI	Beech	99	EURICE		FAA	–	–	–	–	–		Wappingers Falls	New York	USA
W	189	1	6	1977	6-Jan-77	BI	Cessna 180 J		TC (Icing)	A77A0001							Gander Aviation Ltd	Gander AP	Newfoundland	Canada

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E	438	1	15	1977	15-Jan-77	BI	Vickers	Viscount	EURICE		CAA WAAS	–	–	–	–	–	Linjeflyg	Stockholm	—	Sweden
F	82	1	15	1977	15-Jan-77	BI	Vickers Viscount		FSF								Linjeflyg	Near Bromma Airport		
I	14	1	15	1977	15-Jan-77	BI	Vickers VISCOUNT		ICAO	77/0008-0							Linjeflyg	Stockholm	–	Sweden
E	436	2	19	1977	19-Feb-77	BI	Aero	Commander	EURICE		FSF	–	–	–	–	–		Savoonga	Alaska	USA
F	84	2	19	1977	19-Feb-77	BI	Aero Commander 680 FL		FSF									Savoonga	Alaska	
W	224	11	25	1977	25-Nov-77	BI	Cessna 206		TC (Icing)	A77W0119							AO Air Ltd	Ft St. John	British Columbia	Canada
W	201	12	22	1977	22-Dec-77	BI	orth American Commander 520		TC (Icing)	A77F0011								Chester	United States	United States
W	1	2	10	1978	10-Feb-78	BI	Aerostar 601P		TC (Walper)	A78A0001							Ted R Smith Aerostar Corporation	Shearwater	Nova Scotia	Canada
E	426	3	18	1978	18-Mar-78	BI	Beech	Queen Air	EURICE		CAA WAAS	–	–	–	–	–	Vernair Trans Services	Nr Angmagssalik	—	Greenland
F	85	3	18	1978	18-Mar-78	BI	Beech A65 Queen Air		FSF								Vernair Transport Services	Near Angmagssalik		
W	3	4	9	1978	9-Apr-78	BI	Aeronca 7DC		TC (Walper)	A78O0027								McGregor	Ontario	Canada
W	5	4	20	1978	20-Apr-78	BI	Cessna 172 M		TC (Walper)	A78Q0025								Lac Adonis	Quebec	Canada
E	422	11	6	1978	6-Nov-78	BI	Beech	?	EURICE		CAA WAAS	–	–	–	–	–		Jackson	Missouri ?	USA
E	434	11	16	1978	16-Nov-78	BI	Beech	18	EURICE		CAA WAAS	–	–	–	–	–		Hays	Kansas	USA
F	86	11	16	1978	16-Nov-78	BI	Beech G18S		FSF									Hays	Kansas	
E	417	12	2	1978	2-Dec-78	BI	Douglas	DC-3	EURICE		CAA WAAS	–	–	–	–	–		Des Moines	Iowa	USA
F	88	12	2	1978	2-Dec-78	BI	Douglas DC-3		FSF									Des Moines	Iowa	
I	25	12	2	1978	2-Dec-78	BI	Douglas DC-3		ICAO	78/0436-0								Des Moines	Iowa	USA
E	415	12	4	1978	4-Dec-78	BI	Lear	Learjet	EURICE		CAA WAAS	–	–	–	–	–	Richard Sykes	Anchorage	Alaska	USA
E	418	12	4	1978	4-Dec-78	BI	de Havilland Canada	Twin Otter	EURICE		CAA WAAS	–	–	–	–	–	Rocky Mountain Airways	Steamboat Springs	Colorado	USA
F	89	12	4	1978	4-Dec-78	BI	Gates Learjet 25B		FSF									Anchorage	Alaska	
F	90	12	4	1978	4-Dec-78	BI	de Havilland DHC-6		FSF									Steamboat Springs	Colorado	
I	26	12	4	1978	4-Dec-78	BI	Lear-24		ICAO	78/0469-0							Richard Sykes	Anchorage	Alaska	USA
E	409	12	7	1978	7-Dec-78	BI	Cessna	401	EURICE		FSF	–	–	None	–	–		Rockford	Illinois	USA
E	414	12	7	1978	7-Dec-78	BI	Hawker Siddeley	Trident	EURICE		BAe	–	–	–	–	–	British Airways	Bovingdon	?	UK
F	91	12	7	1978	7-Dec-78	BI	Cessna 401A		FSF									Rockford	Illinois	
W	6	12	14	1978	14-Dec-78	BI	Cessna 206		TC (Walper)	A78W0122							Reindeer Air Service Ltd	Inuvik	N W T	Canada
E	407	1	19	1979	19-Jan-79	BI	Lear	Learjet	EURICE		FSF	–	–	None	–	–	Massey Ferguson	Detroit	Michigan	USA
E	408	1	19	1979	19-Jan-79	BI	Piper	Aerostar	EURICE		FSF	–	–	None	–	–		Grand Rapids	Michigan	USA
F	92	1	19	1979	19-Jan-79	BI	Piper Aerostar 601		FSF								Grand Rapids		Michigan	
F	93	1	19	1979	19-Jan-79	BI	Learjet 25D		FSF								Massey Ferguson	Detroit	Michigan	
E	405	3	17	1979	17-Mar-79	BI	Tupolev	Tu-104	EURICE		FSF	–	–	None	–	–		Nr Moscow	–	Russia
F	96	3	17	1979	17-Mar-79	BI	Tupolev Tu-104 Aeroflot		FSF									Near Moscow		
E	404	4	4	1979	4-Apr-79	BI	Beech	18	EURICE		FSF	–	–	None	–	–		Newburgh	New York	USA
F	98	4	4	1979	4-Apr-79	BI	Beech E18		FSF									Newburgh	New York	
W	10	4	4	1979	4-Apr-79	BI	Cessna 401		TC (Walper)	A79O0002							Interstate Aviation	Oshweken	Ontario	Canada
W	12	5	2	1979	2-May-79	BI	Cessna 401		TC (Walper)	A79W0029								Rocky Mtn House	Alberta	Canada
W	13	5	5	1979	5-May-79	BI	Piper PA-34		TC (Walper)	A79W0004								Calgary Int'l	Alberta	Canada
W	9	10	10	1979	10-Oct-79	BI	Piper PA-18-135		TC (Walper)	A79O0124								Hanmer	Ontario	Canada
I	30	11	18	1979	18-Nov-79	BI	LOCKHEED-188 ELECTRA		ICAO	79/0412-0								SALT LAKE CITY		UNITED STATES
E	403	11	18	1979	18-Nov-79	BI	Cessna	Citation	EURICE		FSF	–	–	None	–	–		Castle Rock	Colorado	USA
F	97	11	18	1979	18-Nov-79	BI	Cessna Citation		FSF									Castle Rock	Colorado	
E	3	1	17	1980	17-Jan-80	BI	McDonnell-Douglas	DC-9	EURICE		ICAO	–	–	80/0418-0	–	–		?	?	Finland
I	32	1	17	1980	17-Jan-80	BI	McDonnell-Douglas DC-9-50		ICAO	80/0418-0								HELSINKI A/P	?	Finland
W	19	1	22	1980	22-Jan-80	BI	Bell 206 Jetranger		TC (Walper)	A80Q0006							Trans Quebec Helicopters	Hav St Pierre	Quebec	Canada
E	2	1	30	1980	30-Jan-80	BI	Rockwell	Turbo Commander	EURICE		ICAO	NTSB	–	80/0008-0	E-0004	–		Nr Newcastle	Oklahoma	USA
E	1	2	6	1980	6-Feb-80	BI	BAe	125	EURICE		Bae	–	–	None	–	–	Shell Aviation	Nr Aberdeen	Scotland	UK
E	7	2	15	1980	15-Feb-80	BI	Cessna	340	EURICE		ICAO	FAA	NTSB	80/1303-0	136	3-0220	Air View Aviation	Princeton	New Jersey	USA
I	33	2	16	1980	16-Feb-80	BI	Bristol-175		ICAO	80/0032-0							Redcoat Air Cargo	Billerica	Massachusetts	USA
W	18	2	21	1980	21-Feb-80	BI	Piper PA-32		TC (Walper)	A80O0001								Toronto Int'l	Ontario	Canada
E	9	3	2	1980	2-Mar-80	BI	Douglas	Invader	EURICE		Bae	NTSB	–	None	3-3756	–	University of Nevada	Nr Georgetown	California	USA
F	100	3	2	1980	2-Mar-80	BI	On Mark B-26 Invader		FSF										California	
I	34	3	2	1980	2-Mar-80	BI	Douglas B-26		ICAO	80/1298-0							University of Nevada	Nr Georgetown	California	USA
W	14	3	25	1980	25-Mar-80	BI	Cessna 310 N		TC (Walper)	A80A0004							Miramichi Air Service	Newcastle	New Brunswick	Canada
E	10	3	27	1980	27-Mar-80	BI	Beech	King Air	EURICE		ICAO	FAA	NTSB	80/0276-0	091	3-3783		Nr Parker	Colorado	USA
F	101	4	24	1980	24-Apr-80	BI	Beech 100		FSF									Cedar Rapids	Iowa	
W	20	9	29	1980	29-Sep-80	BI	DeHavilland DHC-2 MK I		TC (Walper)	A80Q0108							Fecteau A. Transport	Lac Rouge	Quebec	Canada
E	11	11	7	1980	7-Nov-80	BI	Cessna	401	EURICE		ICAO	–	–	80/2121-0	–	–		?	?	Canada
W	15	11	7	1980	7-Nov-80	BI	Cessna 402		TC (Walper)	A80C0126							Aero Trades Ltd	Broadview	Saskatchewan	Canada
E	12	11	13	1980	13-Nov-80	BI	Beech	99	EURICE		ICAO	–	–	80/2122-0	–	–		?	?	Canada
W	21	11	13	1980	13-Nov-80	BI	Beech 99		TC (Walper)	A80Q0116							Northern Wings Ltd	Gagnon	Quebec	Canada
E	13	12	6	1980	6-Dec-80	BI	Mitsubishi	MU-2	EURICE		NTSB	–	–	3-3798	–	–		Ramsey	Minnesota	USA
E	14	12	16	1980	16-Dec-80	BI	Mitsubishi	MU-2	EURICE		ICAO	NTSB	–	80/1277-0	3-3451	–		Campbellstown	Ohio	USA
W	16	12	16	1980	16-Dec-80	BI	Cessna 185		TC (Walper)	A80C0136							Jackson Air Services	Sandy Bay	Saskatchewan	Canada
F	102	12	25	1980	25-Dec-80	BI	Dee Howard 500		FSF									Toronto	Ontario	
W	25	1	4	1981	4-Jan-81	BI	Cessna 185		TC (Walper)	A81W0003							Alberta Central Airways	Winefred Lake	Alberta	Canada
F	105	1	16	1981	16-Jan-81	BI	Douglas DC-6A		FSF								Northern Air Cargo	Near Cantwell	Alaska	
I	36	1	16	1981	16-Jan-81	BI	Douglas DC-6A		ICAO	81/0002-0							Northern Air Cargo	Near Cantwell	Alaska	
E	27	1	27	1981	27-Jan-81	BI	Bae	125	EURICE		Bae	–	–	None	–	–	Pennwalt Chemicals	?	Pennsylvania	USA
W	22	3	18	1981	18-Mar-81	BI	Cessna 182 M		TC (Walper)	A81C0021								Craik	Saskatchewan	Canada
E	29	9	2	1981	2-Sep-81	BI	Mitsubishi	MU-2	EURICE		ICAO	NTSB	–	81/0336-0	3-3593	–		McLeod	Texas	USA
E	30	9	6	1981	6-Sep-81	BI	Mitsubishi	MU-2	EURICE		ICAO	NTSB	–	81/0338-0	3-3667	–		Nr Riverton	Wyoming	USA
E	31	10	18	1981	18-Oct-81	BI	Short	330	EURICE		ICAO	NTSB	–	81/1332-0	6-0084	–		Dixon	Illinois	USA
I	38	10	18	1981	18-Oct-81	BI	Short 330		ICAO	81/1332-0								Dixon	Illinois	USA
E	32	11	16	1981	16-Nov-81	BI	Cessna	401	EURICE		ICAO	NTSB	–	81/0306-0	3-3586	–		Dickinson	North Dakota	USA
W	24	11	23	1981	23-Nov-81	BI	Cessna 310 R		TC (Walper)	A81Q0119								Chibougamau	Quebec	Canada
F	104	12	16	1981	16-Dec-81	BI	Boeing 727		FSF								Sterling Airways	Gander	Newfoundland	
E	15			1981		BI	Short	330	EURICE		CAA	–	–	Occurrn 81034780	–	–		?	?	?

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E	16			1981		SI	Short	330	EURICE		CAA	–	–	Occrum 814089E	–	–	Eastern Airways	Norwich	Norfolk	UK
E	21			1981		SI	Avro	748	EURICE		CAA	–	–	Occrum 8100759H	–	–	Dan-Air	Amsterdam		Netherlands
E	22			1981		SI	Avro	748	EURICE		CAA	–	–	Occrum 8101367F	–	–	Dan-Air	Nr Aberdeen	Scotland	UK
E	24			1981		SI	de Havilland	Trident	EURICE		CAA	–	–	Occrum 8100780J	–	–	British Airways	?	?	?
E	44	1	6	1982	6-Jan-82	SI	Cessna	340	EURICE		ICAO	NTSB	–	82/0068-0	0158	–		Rolla	Missouri	USA
E	49	1	13	1982	13-Jan-82	SI	Piper	Navajo	EURICE		ICAO	NTSB	–	82/1230-0	0228	–		Spokane	Washington	USA
E	52	1	19	1982	19-Jan-82	SI	Piper	Aerostar	EURICE		ICAO	FAA	NTSB	82/1209-0	091	0888		University Park	Pennsylvania	USA
E	53	1	21	1982	21-Jan-82	SI	Cessna	401	EURICE		ICAO	NTSB	–	82/0014-0	0243	–		Kansas City	Kansas	USA
E	54	1	22	1982	22-Jan-82	SI	Cessna	Titan	EURICE		ICAO	–	–	82/0039-0	–	–		?	?	Germany
E	56	2	22	1982	22-Feb-82	SI	Cessna	Golden Eagle	EURICE		ICAO	FAA	NTSB	82/0125-0	091	0461		Westerly ?	Rhode Island	USA
W	28	3	28	1982	28-Mar-82	SI	Taylorcraft BC-12D		TC (Walper)	A82W0010								Winnifred Lake	Alberta	Canada
E	58	4	8	1982	8-Apr-82	SI	Short	330	EURICE		FAA	–	–	136	–	–	Mississippi Valley A/L	Moline	Illinois	USA
E	60	6	10	1982	10-Jun-82	SI	Bae	125	EURICE		Bae	–	–	None	–	–	McAlpine Aviation	?	?	France
W	30	9	10	1982	10-Sep-82	SI	Cessna 172 M		TC (Walper)	A82W0080								High Level	Alberta	Canada
W	26	11	11	1982	11-Nov-82	SI	Cessna 310 R		TC (Walper)	A82C0117								Ft Frances	Ontario	Canada
W	27	11	19	1982	19-Nov-82	SI	Cessna 310 R		TC (Walper)	A82C0122							Prairie Flying Service Ltd	Prince Albert	Saskatchewan	Canada
E	36			1982		SI	British Aircraft Corp	111	EURICE		CAA	–	–	Occrum 8201289E	–	–	British Airways	?	?	?
E	70	1	3	1983	3-Jan-83	SI	Cessna	Crusader	EURICE		ICAO	NTSB	–	83/0021-0	237	–		Willard	Washington	USA
N	28	1	3	1983	3-Jan-83	SI	CESSNA CE-303-T303		NTSB	SEA83FA038								WILLARD	WA	United States
E	71	1	11	1983	11-Jan-83	SI	Rockwell	Sabreliner	EURICE		ICAO	–	–	83/2002-0	–	–	Sun Oil Co	Toronto		Canada
I	45	1	11	1983	11-Jan-83	SI	Rockwell		ICAO	83/2002-0							Sun Oil Co	Toronto		Canada
N	29	1	14	1983	14-Jan-83	SI	CESSNA CE-172-G		NTSB	CHI83LA081								GREEN BAY	WI	United States
N	30	1	23	1983	23-Jan-83	SI	CESSNA CE-172		NTSB	CHI83FA089								ROCKFORD	IL	United States
E	72	2	3	1983	3-Feb-83	SI	Rockwell	Turbo Commander	EURICE		ICAO	NTSB	–	83/0040-0	246	–		Sunbury	Pennsylvania	USA
N	1	2	3	1983	3-Feb-83	SI	GULSTM GA-680-FLP		NTSB	NYC83FA050								SUNBURY	PA	United States
N	31	2	7	1983	7-Feb-83	SI	CESSNA CE-210-		NTSB	FTW83LA106								FARMINGTON	NM	United States
W	32	2	8	1983	8-Feb-83	SI	Beech 36		TC (Walper)	A83A0001								Gander	Newfoundland	Canada
W	33	2	13	1983	13-Feb-83	SI	Taylorcraft 19 Sportsman		TC (Walper)	A83C0011								Meadow Lake	Saskatchewan	Canada
N	32	2	27	1983	27-Feb-83	SI	CESSNA CE-150-M		NTSB	DEN83LA067								EMERADO	ND	United States
E	74	3	17	1983	17-Mar-83	SI	McDonnell-Douglas	DC-9	EURICE		ICAO	–	–	83/1211-0	–	–		?	?	USA
I	47	3	17	1983	17-Mar-83	SI	DOUG DC-9-10		ICAO	83/1211-0								SALT LAKE CITY	UT	USA
N	2	3	17	1983	17-Mar-83	SI	DOUG DC-9-10		NTSB	LAX83NA147								SALT LAKE CITY	UT	United States
N	33	3	28	1983	28-Mar-83	SI	CESSNA CE-182-R182		NTSB	CHI83LA154								NORTH CANTON	OH	United States
N	34	5	31	1983	31-May-83	SI	CESSNA CE-182-Q		NTSB	DEN83FA120								COLORADO SPRINGS	CO	United States
N	35	10	1	1983	1-Oct-83	SI	CESSNA CE-182-M		NTSB	LAX84FA002							MICHEAL WOOD		NV	United States
W	37	10	18	1983	18-Oct-83	SI	Cessna 185		TC (Walper)	A83W0080								Langdon	Alberta	Canada
W	34	11	14	1983	14-Nov-83	SI	Cessna 177 A		TC (Walper)	A83P0079								Wood Lake	British Columbia	Canada
N	36	11	22	1983	22-Nov-83	SI	CESSNA CE-414-41		NTSB	DEN84FA030								AURORA	CO	United States
N	37	12	4	1983	4-Dec-83	SI	BEECH BE-77-7		NTSB	CHI84FA054								SIDNEY	OH	United States
N	38	12	6	1983	6-Dec-83	SI	BEECH BE-18-TC45J		NTSB	MKC84FA033								KANSAS CITY	KS	United States
N	39	12	13	1983	13-Dec-83	SI	BEECH BE-36-A		NTSB	FTW84LA097								HARRISON	AR	United States
E	81	12	21	1983	21-Dec-83	SI	Beech	King Air	EURICE		ICAO	FAA	NTSB	83/0398-0	136	2604	Aviex Jet Inc	Detroit	Michigan	USA
F	106	12	21	1983	21-Dec-83	SI	Beechcraft 200		FSF									Detroit	Michigan	
N	3	12	21	1983	21-Dec-83	SI	BEECH BE-200-B200		NTSB	CHI84LA095							AVIEX JET	DETROIT	MI	United States
N	40	12	23	1983	23-Dec-83	SI	CESSNA CE-182-R182		NTSB	ATL84LA074							ARROWHEAD AIRWAYS, INC	PENNINGTON GAP	VA	United States
N	41	12	26	1983	26-Dec-83	SI	BEECH BE-36-P36		NTSB	DEN84FA049							GEORGE CHAMBERLIN	DOVE CREEK	CO	United States
N	4	12	27	1983	27-Dec-83	SI	BEECH BE-58-58		NTSB	FTW84FA104							CHARLES F. MCCOOL,FREY ABS E	MARQUEZ	MI	United States
E	61			1983		SI	Short	330	EURICE		CAA	–	–	Occrum 8300054B	–	–	Inter City Airways	?	North Wales	UK
E	63			1983		SI	Bae	Jetstream 31	EURICE		CAA	–	–	Occrum 8303636X	–	–		?	North Sea	UK
E	64			1983		SI	Bae	Jetstream 31	EURICE		CAA	–	–	Occrum 8302563D	–	–	Peregrine Airlines	?	?	?
E	65			1983		SI	Bae	Jetstream 31	EURICE		CAA	–	–	Occrum 8303818E	–	–	Peregrine Airways	?	?	?
E	66			1983		SI	BAe	Jetstream 31	EURICE		CAA	–	–	Occrum 8303753E	–	–		?	?	?
E	67			1983		SI	Bae	Jetstream 31	EURICE		CAA	–	–	Occrum 8301620A	–	–		Nr Birmingham	Midlands	UK
E	68			1983		SI	Bae	Jetstream 31	EURICE		CAA	–	–	Occrum 8301621X	–	–		Nr Birmingham	Midlands	UK
E	69			1983		SI	Bae	Jetstream 31	EURICE		CAA	–	–	Occrum 8302200B	–	–	Peregrine Airlines	?	?	?
N	42	1	2	1984	2-Jan-84	SI			NTSB	LAX84FA129								BOWIE	AZ	United States
W	38	1	3	1984	3-Jan-84	SI	Piper PA-32		TC (Walper)	A84C0001								Shoal Lake	Manitoba	Canada
E	100	1	11	1984	11-Jan-84	SI	Bae	125	EURICE		Bae	–	–	None	–	–	RAF	Nr Elvington	Yorkshire	UK
E	101	1	13	1984	13-Jan-84	SI	Bae	125	EURICE		Bae	–	–	None	–	–	Hareco	Harrisburg	Pennsylvania	USA
E	103	1	14	1984	14-Jan-84	SI	Fairchild	Metro	EURICE		ICAO	NTSB	–	84/0301-0	5022	–	Trans Colorado Airlines	Durango	Colorado	USA
N	43	1	14	1984	14-Jan-84	SI	SWRNGN SA-227-AC		NTSB	DEN84IA070							TRANS COLORADO AIRLINE	DURANGO	CO	United States
N	44	1	15	1984	15-Jan-84	SI	CESSNA CE-182		NTSB	ATL84LA081								DALTON	GA	United States
N	46	1	18	1984	18-Jan-84	SI	CESSNA CE-177-B		NTSB	ATL84FA082								LAFAYETTE	GA	United States
E	104	1	20	1984	20-Jan-84	SI	Cessna	Citation	EURICE		ICAO	NTSB	–	84/1295-0	5001	–		Yakima	Washington	USA
W	40	1	28	1984	28-Jan-84	SI	Cessna 180 J		TC (Walper)	A84W0004								Innisfail	Alberta	Canada
N	12	2	3	1984	3-Feb-84	SI	PIPER PA-60-602P		NTSB	CHI84LA102								BELLAIRE	MI	United States
N	48	2	3	1984	3-Feb-84	SI	CESSNA CE-402-C		NTSB	NYC84FA061								JAFFREY	NH	United States
E	106	2	21	1984	21-Feb-84	SI	Fairchild	Metro	EURICE		ICAO	–	–	84-0014-0	–	–		Reykjavik	—	Iceland
E	107	3	19	1984	19-Mar-84	SI	Beech	18	EURICE		ICAO	NTSB	FAA	84/0236-0	3183	136	Empire Aero Services	Monticello	New York	USA
N	47	3	19	1984	19-Mar-84	SI	BEECH BE-36-A36TC		NTSB	MKC84FA106							MEMPHIS JET CENTER	WEBB CITY	MO	United States
E	108	3	21	1984	21-Mar-84	SI	Cessna	Golden Eagle	EURICE		ICAO	–	–	84/0739-0	–	–		?	?	USA
W	47	3	25	1984	25-Mar-84	SI	Hughes 369HS		TC (Walper)	A84W0018							Delta Helicopters Ltd	Footner Lake	Alberta	Canada
E	109	4	1	1984	1-Apr-84	SI	Cessna	Golden Eagle	EURICE		ICAO	NTSB	–	84/1080-0	892	–		Douglas	Wyoming	USA
N	45	4	1	1984	1-Apr-84	SI	CESSNA CE-414-A		NTSB	DEN84FA122								DOUGLAS	WY	United States
N	49	4	6	1984	6-Apr-84	SI	BEECH BE-35-N		NTSB	SEA84FA078								BAKER	OR	United States
N	50	4	24	1984	24-Apr-84	SI	PIPER PA-32RT-300		NTSB	NYC84FA148								HOPWOOD	PA	United States
N	51	8	1	1984	1-Aug-84	SI	CESSNA CE-421-C		NTSB	DEN84MA247								FORT LUPTON	CO	United States
E	116	10	23	1984	23-Oct-84	SI	Cessna	Golden Eagle	EURICE		ICAO	NTSB	–	84/0181-0	3251	–		Cheyenne	Wyoming	USA

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N	52	10	23	1984	23-Oct-84	SI	CESSNA CE-414-414		NTSB	DEN85FA017								CHEYENNE	WY	United States
W	40	10	25	1984	25-Oct-84	SI	DeHavilland DHC-2 MK I		TC (Walper)	A84C0086							Stewart Lake Airways Ltd	Stewart Lake	Ontario	Canada
W	42	10	25	1984	25-Oct-84	SI	Mitsubishi MU-2		TC (Walper)	A84P4013							Flight Center Victoria	Enderby	British Columbia	Canada
E	118	11	5	1984	5-Nov-84	SI	Rockwell	Sabreliner	EURICE		ICAO	NTSB	–	84/1080-0	5083	–		Chicago	Illinois	USA
I	80	11	5	1984	5-Nov-84	SI	Rockwell SABRE 40		ICAO	84/1080-0								Chicago	Illinois	USA
N	5	11	5	1984	5-Nov-84	SI	NAMER NA-265-265		NTSB	CHI85IA038								CHICAGO	IL	United States
E	117	11	12	1984	12-Nov-84	SI	Cessna	Golden Eagle	EURICE		ICAO	–	–	84/2065-0	–	–		?	?	Canada
W	41	11	12	1984	12-Nov-84	SI	Cessna 414		TC (Walper)	A84O0806								Toronto Island	Ontario	Canada
N	63	11	19	1984	19-Nov-84	SI	CESSNA CE-172-P		NTSB	FTW85LA058								PAMPA	TX	United States
E	119	11	27	1984	27-Nov-84	SI	Cessna	Golden Eagle	EURICE		ICAO	NTSB	–	84/0358-0	3306	–	Skytrak Aviation	Mason City	Iowa	USA
N	64	11	27	1984	27-Nov-84	SI	CESSNA CE-421-B		NTSB	MKC85LA026							SKYTRAK AVIATION	MASON CITY	IA	United States
N	29	12	4	1984	4-Dec-84	SI	CESSNA CE-310-R		NTSB	FTW85LA068								LUBBOCK	TX	United States
N	65	12	13	1984	13-Dec-84	SI	CESSNA CE-172-R172K		NTSB	LAX85FA070								DESERT CENTER	CA	United States
E	120	12	14	1984	14-Dec-84	SI	Cessna	340	EURICE		ICAO	NTSB	–	84/1156-0	3027	–	Air Transport Inc	Odessa	Texas	USA
N	66	12	14	1984	14-Dec-84	SI	CESSNA CE-340-3		NTSB	FTW85LA077								ODESSA	TX	United States
W	43	12	14	1984	14-Dec-84	SI	Cessna 414		TC (Walper)	A84P4016							Seymore Air Ltd	Castlegar AP	British Columbia	Canada
N	67	12	18	1984	18-Dec-84	SI	MOONEY MOONEY-20-J		NTSB	LAX85FA073								GRAND CANYON	AZ	United States
W	39	12	20	1984	20-Dec-84	SI	Cessna 172 M		TC (Walper)	A84C0073							Battleford Air	Beauval	Saskatchewan	Canada
E	122	12	24	1984	24-Dec-84	SI	Saab	SF340	EURICE		Bae	–	–	None	–	–	Air Midwest	?	?	USA
N	68	12	24	1984	24-Dec-84	SI	BEECH BE-58-5		NTSB	CHI85LA082								FLINT	MI	United States
E	83			1984		SI	Short	330	EURICE		CAA	–	–	Occnum 8400198H	–	–	Air UK	Amsterdam		Netherlands
E	84			1984		SI	Short	330	EURICE		CAA	–	–	Occnum 8400275A	–	–	Avair	Birmingham	Midlands	UK
E	86			1984		SI	Short	360	EURICE		CAA	–	–	Occnum 8403894J	–	–	Air Ecosse	London		UK
E	88			1984		SI	Aero	748	EURICE		CAA	–	–	Occnum 8400047C	–	–	CAA	?	?	?
E	90			1984		SI	Bae	Jetstream 31	EURICE		CAA	–	–	Occnum 8400123B	–	–		Birmingham	Midlands	UK
E	91			1984		SI	Bae	Jetstream 31	EURICE		CAA	–	–	Occnum 8403423H	–	–	McAlpine Aviation	?	?	?
E	92			1984		SI	Bae	Jetstream 31	EURICE		CAA	–	–	Occnum 8403898J	–	–	Euroflite	?	?	?
E	93			1984		SI	Bae	Jetstream 31	EURICE		CAA	–	–	Occnum 8400111J	–	–		Birmingham	Midlands	UK
E	94			1984		SI	Bae	Jetstream 31	EURICE		CAA	–	–	Occnum 8400122D	–	–		Birmingham	Midlands	UK
E	96			1984		SI	Vickers	Viscount	EURICE		CAA	–	–	Occnum 8400043X	–	–	British Midland Airways	?	?	?
E	97			1984		SI	Vickers	Viscount	EURICE		CAA	–	–	Occnum 8400115A	–	–	British Midland Airways	?	?	?
E	98			1984		SI	Vickers	Viscount	EURICE		CAA	–	–	Occnum 8400018X	–	–	Manx Airlines	?	?	?
N	59	1	7	1985	7-Jan-85	SI	CESSNA CE-182-R1		NTSB	ATL85FA077								CROSSVILLE	TN	United States
N	60	1	17	1985	17-Jan-85	SI	CESSNA CE-340-3		NTSB	ATL85FA079								JOHNSON CITY	TN	United States
N	61	1	30	1985	30-Jan-85	SI	BEECH BE-60-B60		NTSB	ATL85FA086								EDGEWOOD	KY	United States
E	133	2	4	1985	4-Feb-85	SI	Beech	Queen Air	EURICE		ICAO	NTSB	–	85/0014-0	387	–	North Pacific Airlines	Soldotna	Alaska	USA
F	108	2	4	1985	4-Feb-85	SI	Beech 65-A80		FSF								North Pacific Airlines	Soldotna	Alaska	
N	13	2	4	1985	4-Feb-85	SI	BEECH BE-65-A80		NTSB	DCA85AA012							NORTH PACIFIC AIRLINES	SOLDOTNA	AK	United States
I	86	2	11	1985	11-Feb-85	SI	Bae-31		ICAO	85/1011-0								MACON	Georgia	USA
N	62	2	25	1985	25-Feb-85	SI	CESSNA CE-210-C		NTSB	DEN85LA086								FORT BRIDGER	WY	United States
N	63	2	28	1985	28-Feb-85	SI	BEECH BE-36-A36		NTSB	CHI85LA124								TRAVERSE CITY	MI	United States
E	141	3	12	1985	12-Mar-85	SI	de Havilland Canada	Twin Otter	EURICE		NTSB	Bae	NLR	614	None	None	SEAIR Alaska Airlines	Barter Island	Alaska	USA
N	64	3	13	1985	13-Mar-85	SI	PIPER PA-32-260		NTSB	CHI85FA130							MILLER FLYING SERVICE	ANGOLA	IN	United States
E	142	3	17	1985	17-Mar-85	SI	Cessna	Golden Eagle	EURICE		ICAO	–	–	85/0073-0	–	–		Nr Frankfurt	?	Germany
N	65	3	25	1985	25-Mar-85	SI	LAKE LA-4-200		NTSB	NYC85FA088								SWANTON	VT	United States
N	66	4	7	1985	7-Apr-85	SI	MOONEY MOONEY-20		NTSB	NYC85FA103								LOCK HAVEN	PA	United States
N	67	4	7	1985	7-Apr-85	SI	CESSNA CE-210		NTSB	CHI85FA157								MUNCIE	IN	United States
N	68	4	18	1985	18-Apr-85	SI	CESSNA CE-210-T21		NTSB	LAX85LA211								WHITE MOUNTAIN LAKES ESTATE	AZ	United States
N	69	4	21	1985	21-Apr-85	SI	HELIO HELIO-295-295		NTSB	SEA85LA094								JOHN DAY	OR	United States
N	70	4	21	1985	21-Apr-85	SI	BEECH BE-36-B36TC		NTSB	DEN85LA122							RICHARD MCGUIRE	SILVER CITY	NM	United States
W	51	6	6	1985	6-Jun-85	SI	Beech TC-45J		TC (Walper)	A85C0033							Keewatin Air Ltd	Coral Harbour	N.W.T.	Canada
N	71	10	5	1985	5-Oct-85	SI			NTSB	DEN86LA008							DR. JAMES O. JONES	PECOS	NM	United States
E	144	11	5	1985	5-Nov-85	SI	Saab	SF340	EURICE		Bae	–	–	None	–	–		?	?	?
E	145	11	9	1985	9-Nov-85	SI	Boeing	737	EURICE		FAA	–	–	121	–	–	United Airlines	Los Angeles	California	USA
N	14	11	16	1985	16-Nov-85	SI	CESSNA CE-421-C		NTSB	SEA86LA024								IDAHO FALLS	ID	United States
E	146	11	20	1985	20-Nov-85	SI	Cessna	Golden Eagle	EURICE		ICAO	–	–	85/0349-0	–	–		Dortmund	?	Germany
E	147	11	26	1985	26-Nov-85	SI	Rockwell	Commander 500	EURICE		ICAO	NTSB	–	85/0385-0	2895	–		Des Moines	Iowa	USA
N	72	11	26	1985	26-Nov-85	SI	GULSTM GA-500-S		NTSB	MKC86MA031							IOWA STATE UNIVERSITY	DES MOINES	IA	United States
N	73	11	29	1985	29-Nov-85	SI	BEECH BE-35-35		NTSB	CHI86FA035							EUGENE BOUSKA	ODELL	IL	United States
E	148	12	1	1985	1-Dec-85	SI	Bae	Jetstream 31	EURICE		FAA	–	–	136	–	–	Express Airlines	Fort Smith	Arkansas	USA
W	63	12	12	1985	12-Dec-85	SI	McDonnell Douglas DC-8-63		TC (Walper)	A85H0902							Arrow Air	Gander AP	Newfoundland	Canada
E	387	12	16	1985	16-Dec-85	SI	Cessna	Stationair	EURICE			–	–		–	–	Ryan Air Services	Napaskiak	Alaska	USA
F	114	12	16	1985	16-Dec-85	SI	Cessna C-207		FSF								Ryan Air Service	Napaskiak	Alaska	
N	74	12	16	1985	16-Dec-85	SI	CESSNA CE-207-A		NTSB	ANC86FA014							RYAN AIR SERVICE	NAPASKIAK	AK	United States
W	52	12	21	1985	21-Dec-85	SI	orth American Commander 500B		TC (Walper)	A85C0096							Aero-North Aviation Services	Fond du Lac	Saskatchewan	Canada
N	75	12	22	1985	22-Dec-85	SI	CESSNA CE-177-B		NTSB	CHI86MA052								BROOKLYN	MI	United States
E	124			1985		SI	Bae	Jetstream 31	EURICE		CAA	–	–	Occnum 8500446X	–	–	RAF	?	?	UK ?
E	127			1985		SI	Saab	SF340	EURICE		CAA	–	–	Occnum 8502517H	–	–	Birmingham Exec Al.	?	?	?
E	128			1985		SI	Vickers	Viscount	EURICE		CAA	–	–	Occnum 8501520B	–	–	British Midland Airways	?	?	?
N	76	1	6	1986	6-Jan-86	SI	CESSNA CE-140-1		NTSB	SEA86LA039								IONE	OR	United States
E	101	1	10	1986	10-Jan-86	SI	Fokker	F27	EURICE		ICAO	–	–	86/0379-0	–	–		?	?	Germany
E	102	1	31	1986	31-Jan-86	SI	Short	360	EURICE		ICAO	Bae	NLR	86/0005-0	None	None	Aer Lingus	Castle Donington	East Midlands	UK
F	115	1	31	1986	31-Jan-86	SI	Shorts SD3-60		FSF								Aer Lingus Commuter	East Midlands Airport		
I	65	1	31	1986	31-Jan-86	SI	Shorts 360		ICAO	86/0005-0							Aer Lingus	Castle Donington	East Midlands	UK
E	103	2	2	1986	2-Feb-86	SI	Short	360	EURICE		Bae	–	–	None	–	–		Nr Manchester	Yorkshire	UK
E	104	2	2	1986	2-Feb-86	SI	de Havilland Canada	Dash 8	EURICE		Trans Can	–	–	A8600006	–	–	Air-Dale	Sault St Marie		Canada
N	77	2	2	1986	2-Feb-86	SI	CESSNA CE-180-K		NTSB	DEN86FA071								KALISPELL	MT	United States
N	78	2	11	1986	11-Feb-86	SI	CESSNA CE-207-A		NTSB	ANC86MA027								NOME	AK	United States

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E	165	2	18	1986	18-Feb-86	SI	Cessna	401	EURICE		ICAO	–	–	86/0044-0	–	–		?	?	USA
E	166	2	19	1986	19-Feb-86	SI	Cessna	340	EURICE		ICAO	FAA	–	86/0045-0	136	–	AAR Western Skyways	Burns	Oregon	USA
N	79	2	19	1986	19-Feb-86	SI	CESSNA CE-340-340		NTSB	SEA86LA060							AAR WESTERN SKYWAYS, INC	BURNS	OR	United States
N	80	3	10	1986	10-Mar-86	SI	PIPER PA-24-260		NTSB	DEN86FA098							OPRTR-CERTIFICATES	TH OR CONSEQUENCES	NM	United States
E	168	3	23	1986	23-Mar-86	SI	Avro	748	EURICE		Bse	–	–	None	–	–		?	?	?
E	169	4	4	1986	4-Apr-86	SI	IAI	Westwind	EURICE		Bse	–	–	None	–	–		?	Texas	USA
N	81	4	18	1986	18-Apr-86	SI	PIPER PA-18-160		NTSB	LAX86LA181							UNION FLIGHTS	COLUSA	CA	United States
E	171	5	18	1986	18-May-86	SI	Beech	99	EURICE		ICAO	–	–	86/0153-0	–	–	Centennial Airlines	Laramie	Wyoming	USA
F	116	5	18	1986	18-May-86	SI	Beech 99C		FSF								Centennial Airlines Laramie		Wyoming	
N	82	5	18	1986	18-May-86	SI	BEECH BE-99-C99		NTSB	DEN86FA137							CENTENNIAL AIRLINES, INC	LARAMIE	WY	United States
N	83	11	6	1986	6-Nov-86	SI	PIPER PA-32-301T		NTSB	DEN87FA017							VLADIMIR RIHA	CHEYENNE	WY	United States
E	172	11	20	1986	20-Nov-86	SI	ATR	42	EURICE		Bse	–	–	None	–	–		?	?	USA ?
N	84	11	29	1986	29-Nov-86	SI	PIPER PA-60-601P		NTSB	ATL87FA030								CLINTON	NC	United States
N	85	11	30	1986	30-Nov-86	SI	CESSNA CE-150-M		NTSB	MKC87FA027								COLBY	KS	United States
N	86	12	7	1986	7-Dec-86	SI	PIPER PA-18-18		NTSB	ANC87LA019								SHAGELUK	AK	United States
E	173	12	10	1986	10-Dec-86	SI	Cessna	Golden Eagle	EURICE		ICAO	–	–	86/2083-0	–	–		?	?	Canada
W	62	12	10	1986	10-Dec-86	SI	Beech 200		TC (Walper)	A86W0070								Ft McMurray	Alberta	Canada
N	87	12	13	1986	13-Dec-86	SI	PIPER PA-22-160		NTSB	CHI87LA040								MC GRATH	MN	United States
E	175	12	16	1986	16-Dec-86	SI	Avro	748	EURICE		Bse	–	–	None	–	–		?	?	?
E	176	12	18	1986	18-Dec-86	SI	ATR	42	EURICE		NTSB	–	–	5083	–	–	Simmons Airlines	Detroit	Michigan	USA
N	15	12	18	1986	18-Dec-86	SI	AEROSP ATR-42-300		NTSB	DCA87IA015								DETROIT	MI	United States
N	88	12	22	1986	22-Dec-86	SI	BLANCA BL-1419-3A		NTSB	CHI87FA054								WEST CHICAGO	IL	United States
N	89	12	29	1986	29-Dec-86	SI	PIPER PA-32-301		NTSB	CHI87FA057							TRADEWINDS AVIATION, INC	WHEELING	IL	United States
W	57	12	30	1986	30-Dec-86	SI	Piper PA-34		TC (Walper)	A86C0110							Keystone Air Service Ltd	Swan river	Manitoba	Canada
E	154			1986		SI	British Aircraft Corp	111	EURICE		CAA	–	–	Occrum 8600478F	–	–	British Airways	Edinburgh	Scotland	UK
E	155			1986		SI	British Aircraft Corp	111	EURICE		CAA	–	–	Occrum 8603916J	–	–	British Airways	?	?	?
E	156			1986		SI	British Aircraft Corp	111	EURICE		CAA	–	–	Occrum 8604452B	–	–	British Airways	Aberdeen	Scotland	UK
E	158			1986		SI	Short	330	EURICE		CAA	–	–	Occrum 86 002259	–	–	Air Ecosse	Dover	Kent	UK
E	159			1986		SI	Fokker	F27	EURICE		CAA	–	–	Occrum 8600500E	–	–	Air UK	?	?	?
E	160	1	18	1987	18-Jan-87	SI	Fokker	F27	EURICE		ICAO	Bse	NLR	87/0024-0	None	None	British Midland Airways	Castle Donnington	East Midlands	UK
F	119	1	18	1987	18-Jan-87	SI	Fokker F-27		FSF								British Midland Airways	Castle Donington Race Track		
I	65	1	18	1987	18-Jan-87	SI	Fokker F-27		ICAO	87/0024-0							British Midland Airways	Castle Donington Race Track		
N	90	1	24	1987	24-Jan-87	SI	CESSNA CE-182-R		NTSB	SEA87LA052							CORPORATE AIR SERVICES	SPOKANE	WA	United States
W	64	1	31	1987	31-Jan-87	SI	DeHavilland DHC-3		TC (Walper)	A87C0004							C & M Airways	Springwater	Saskatchewan	Canada
N	91	2	20	1987	20-Feb-87	SI	CESSNA CE-210-T210N		NTSB	DEN87FA067							TRI STATE DRILLING & EQUIPME	WEST FARGO	ND	United States
E	162	2	21	1987	21-Feb-87	SI	Fokker	F28	EURICE		Bse	–	–	None	–	–		Reykjavik	—	Iceland
F	120	2	21	1987	21-Feb-87	SI	Fokker F-28		FSF									Reykjavik		
N	92	3	15	1987	15-Mar-87	SI	PIPER PA-32-300		NTSB	MKC87LA082								MASON CITY	IA	United States
E	164	4	28	1987	28-Apr-87	SI	Piper	Aztec	EURICE		ICAO	NTSB	–	87/0077-0	1277	–	Corporate Air	Portland	Maine	USA
N	93	4	28	1987	28-Apr-87	SI	PIPER PA-23-250		NTSB	NYC87LA135								PORTLAND	ME	United States
E	167	10	15	1987	15-Oct-87	SI	ATR	42	EURICE		ICAO	Bse	NLR	87/0184-0	None	None	Aero Transporti Italia	Nr Lecco	Mount Crezzo	Italy
E	168	10	15	1987	15-Oct-87	SI	Douglas	DC-8	EURICE		Bse	–	–	None	–	–		Nr Milan	—	Italy
E	169	10	15	1987	15-Oct-87	SI	Beech	King Air	EURICE		Bse	–	–	None	–	–		Nr Milan	—	Italy
F	121	10	15	1987	15-Oct-87	SI	ons de Transport Regional ATR-42		FSF								Aero Transporti Italiani	Mount Crezzo		
I	66	10	15	1987	15-Oct-87	SI	ATR 42		ICAO	87/0184-0							Aero Transporti Italia	Nr Lecco	Mount Crezzo	Italy
N	94	11	13	1987	13-Nov-87	SI	CESSNA CE-180-G		NTSB	SEA88FA024								CAMBRIDGE	ID	United States
N	95	11	14	1987	14-Nov-87	SI	MOONEY MOONEY-20-K		NTSB	NYC88FA042								DANBY	VT	United States
W	65	11	22	1987	22-Nov-87	SI	Piper PA-28		TC (Walper)	A87A0805								Goose Bay	Newfoundland	Canada
E	182	11	23	1987	23-Nov-87	SI	Beech	1900	EURICE		ICAO	Bse	NLR	87/0300-0	None	None	Ryan Air	Homer	Alaska ?	USA
F	123	11	23	1987	23-Nov-87	SI	Beechcraft 1900		FSF								Ryan Air Service	Near Homer	Alaska	
I	68	11	23	1987	23-Nov-87	SI	BEECH BE-1900-1900		ICAO	87/0300-0								HOMER	AK	United States
N	96	11	23	1987	23-Nov-87	SI	BEECH BE-1900-1900		NTSB	DCA88MA005								HOMER	AK	United States
N	97	11	25	1987	25-Nov-87	SI	BEECH BE-35-J35		NTSB	DEN88FA030								KNOLLS	UT	United States
N	98	11	28	1987	28-Nov-87	SI	CESSNA CE-210-T210N		NTSB	NYC88FA045								SKANEATELES	NY	United States
N	99	11	28	1987	28-Nov-87	SI	MOONEY MOONEY-20-J		NTSB	MKC88LA022							DONALD E. KEIFER	SPRINGDALE	AR	United States
N	100	12	10	1987	10-Dec-87	SI	CESSNA CE-177-RG		NTSB	DEN88FA128								AFTON	WY	United States
E	183	12	14	1987	14-Dec-87	SI	Bae	Jetstream 31	EURICE		Bse	–	–	None	–	–		Joplin	Missouri	USA
F	124	12	17	1987	17-Dec-87	SI	Swearingen SA-226		FSF								Avair	Chantilly	Virginia	
E	186	12	21	1987	21-Dec-87	SI	Short	330	EURICE		Bse	–	–	None	–	–		Norrkoping	—	Sweden
N	101	12	28	1987	28-Dec-87	SI	PIPER PA-28RT-201T		NTSB	MKC88LA033							BILL MORRISON	HAYS	KS	United States
N	102	12	31	1987	31-Dec-87	SI	PIPER PA-32RT-300		NTSB	NYC88FA082							PUAL H. SPILLER	BURLINGTON	VT	United States
N	103	1	6	1988	6-Jan-88	SI	BEECH BE-36-B36TC		NTSB	FTW88FA046								WOODWARD	OK	United States
N	104	1	10	1988	10-Jan-88	SI	BEECH BE-36-A36		NTSB	CHI88LA044								ST PAUL	MN	United States
N	105	1	31	1988	31-Jan-88	SI	CESSNA CE-182-R		NTSB	DEN88LA073								PUEBLO	CO	United States
E	208	2	17	1988	17-Feb-88	SI	Short	330	EURICE		Bse	–	–	None	–	–		?	?	Sweden
N	106	3	4	1988	4-Mar-88	SI	BEECH BE-36-A36		NTSB	ATL88FA104							CONSOLE CORP.	BOW	KY	United States
N	107	4	21	1988	21-Apr-88	SI	CESSNA CE-182-J		NTSB	DEN88FA100								RAPID CITY	SD	United States
E	212	5	26	1988	26-May-88	SI	Cessna	Golden Eagle	EURICE		ICAO	–	–	88/0140-0	–	–		?	?	USA
N	108	5	26	1988	26-May-88	SI	CESSNA CE-421-C		NTSB	LAX88FA215							JOHN D. MAC DONALD	SHAVER LAKE	CA	United States
N	109	6	8	1988	8-Jun-88	SI	BEECH BE-36-A36		NTSB	SEA88LA107							JOHN COLLINS	WENATCHEE	WA	United States
E	214	6	9	1988	9-Jun-88	SI	Cessna	Golden Eagle	EURICE		ICAO	NTSB	–	88/0152-0	1375	–		Knoxville	Tennessee	USA
N	110	6	9	1988	9-Jun-88	SI	CESSNA CE-421-B		NTSB	ATL88FA191								KNOXVILLE	TN	United States
N	111	10	9	1988	9-Oct-88	SI	CESSNA CE-206-U206G		NTSB	NYC89LA009							ROBERT HAGELIN	RUTLAND	VT	United States
S	10	10		1988	Oct-88	SI	LRG		NASA	90530								ORD	IL	
I	71	11	2	1988	2-Nov-88	SI	NA-1121 Jet Commander		ICAO	88/0298-0								Oak Grove	Pennsylvania	USA
N	112	11	19	1988	19-Nov-88	SI	PIPER PA-28RT-201T		NTSB	NYC89FA036							JAMES JACOBS/DANIEL FERRI	GANS	PA	United States
N	113	11	19	1988	19-Nov-88	SI	BEECH BE-36-A36		NTSB	FTW89FA023							MILLER, DAVID D.	OKLAHOMA CITY	OK	United States
E	216	12	9	1988	9-Dec-88	SI	Rockwell	Commander 500	EURICE		ICAO	–	–	88/0443-0	–	–		Knoxville	Tennessee	USA

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E	200	12	16	1988	16-Dec-88	SI	Mitsubishi	MU-2	EURICE		Bae	–	–	None	–	–	Broughton Air Services	Nr Leonora Airfield	?	Australia
F	126	12	16	1988	16-Dec-88	SI	Mitsubishi MU-2B-60		FSF								Broughton Air Services	Near Leonora Airfield		
E	399	12	21	1988	21-Dec-88	SI	Cessna	Stationair	EURICE			–	–		–	–	Baker Aviation	Kotzebue	Alaska	USA
F	127	12	21	1988	21-Dec-88	SI	Cessna 207		FSF								Baker Aviation	Kotzebue	Alaska	
E	219	12	22	1988	22-Dec-88	SI	ATR	42	EURICE		NTSB	–	–	6115	–	–	Simmons Airlines	Mosinee	Wisconsin	USA
E	220	12	22	1988	22-Dec-88	SI	Cessna	Golden Eagle	EURICE		ICAO	–	–	88/0446-0	–	–		Nr Cleveland	Ohio	USA
N	6	12	22	1988	22-Dec-88	SI	AEROSP ATR-42-300		NTSB	CHI89IA034							SIMMONS AIRLINES	MOSINEE	WI	United States
N	114	12	22	1988	22-Dec-88	SI	CESSNA CE-414-A		NTSB	ATL89FA058							DONALD I. KAPETANSKY	BLOOMVILLE	OH	United States
E	222	12	28	1988	28-Dec-88	SI	Bae	Jetstream 31	EURICE		Bae	–	–	None	–	–		Indianapolis	Indiana	USA
E	197			1988		SI	Bae	146	EURICE		Bae	–	–	None	–	–	Air UK	?	?	?
E	198			1988		SI	Short	330	EURICE		CAA	–	–	Occnum 8800787A	–	–	Avia	Oralbo ?	?	?
E	201			1988		SI	Fairchild	Metro	EURICE		CAA	–	–	Occnum 880057E	–	–	TAT	Pamfou	—	France
E	202			1988		SI	Vickers	Viscount	EURICE		CAA	–	–	Occnum 8801318G	–	–	Manx Airlines	?	?	?
E	208			1988		SI	ATR	42	EURICE		Bae	–	–	None	–	–		Nr Rome	—	Italy
E	217			1988		SI	ATR	42	EURICE		Bae	–	–	None	–	–		Nr Mosinee	Wisconsin	USA
N	115	1	2	1989	2-Jan-89	SI	PIPER PA-28RT-201T		NTSB	CHI89FA040							HENSON, KEITH A.	CARMEL	IN	United States
N	116	1	10	1989	10-Jan-89	SI	BEECH BE-35-B33		NTSB	LAX89FA082							RICHARD ENTERPRISES, INC	RIPON	CA	United States
N	117	1	14	1989	14-Jan-89	SI	PIPER PA-28-180		NTSB	CHI89LA045								VALPARAISO	IN	United States
N	118	1	14	1989	14-Jan-89	SI	CESSNA CE-180-180		NTSB	ATL89LA075							GEIGER, RICHARD G.	RUSSELLS POINT	OH	United States
N	119	1	26	1989	26-Jan-89	SI	GULSTM GA-7-7		NTSB	NYC89FA073							DAVID W. SWEIGART	PARTANBURG	PA	United States
N	120	2	12	1989	12-Feb-89	SI	PIPER PA-24-260		NTSB	LAX89FA106								JULIAN	CA	United States
E	229	2	26	1989	26-Feb-89	SI	Fairchild	Metro	EURICE		FAA	–	–	136	–	–	Big Sky Transportation	Billings	Montana	USA
N	7	3	2	1989	2-Mar-89	SI	CESSNA CE-310-Q		NTSB	MKC89LA073							MID PLAINS AVIATION	NORFOLK	NE	United States
E	230	3	4	1989	4-Mar-89	SI	Piper	Aerostar	EURICE		ICAO	–	–	89/0085-0	–	–		?	?	USA
N	121	3	4	1989	4-Mar-89	SI	CESSNA CE-185-185		NTSB	SEA89LA084							REGINALD T. PFEIFFER	BELLINGHAM	WA	United States
E	233	3	15	1989	15-Mar-89	SI	NAMC	YS-11	EURICE		ICAO	NTSB	Bae	89/0098-0	590	None	Mid Pacific Airlines	West Lafayette	Indiana	USA
F	129	3	15	1989	15-Mar-89	SI	NAMC YS-11 Mid Pacific Airlines		FSF								Purdue University		Indiana	
I	74	3	15	1989	15-Mar-89	SI	NAMC-YS-11A		ICAO	89/0098-0								WEST LAFAYETTE	UNITED STATES	
N	10	3	15	1989	15-Mar-89	SI	NIHON YS-11A-600		NTSB	CHI89MA057							MID PACIFIC AIRLINES	WEST LAFAYETTE	IN	United States
I	75	3	24	1989	24-Mar-89	SI	Short-360		ICAO	89/1167-0								ALBANY	?	USA
N	122	5	23	1989	23-May-89	SI	AYRES AYRES-S2-R		NTSB	LAX89LA202									AO	United States
E	390	6	28	1989	28-Jun-89	SI	Embraer	Brasilia	EURICE		FAA	–	–	None	–	–	United Express	Klamath Falls	Oregon	USA
N	123	9	4	1989	4-Sep-89	SI	CESSNA CE-182-182		NTSB	SEA89LA164							EVERGREEN FLYING CLUB	LESTER	WA	United States
S	14	9		1989	Sep-89	SI	MLG		NASA	122002								PWE	NE	
N	124	11	6	1989	6-Nov-89	SI	CESSNA CE-172-M		NTSB	SEA90FA133								SNOQUALMIE	WA	United States
N	125	11	22	1989	22-Nov-89	SI	PIPER PA-32R-300		NTSB	NYC90LA032							A & G AIR OF N.J., INC.	JOHNSTOWN	PA	United States
N	126	11	25	1989	25-Nov-89	SI	PIPER PA-28-140		NTSB	DEN90LA026							MCCOSH, JOSEPH D.	TEAMBOAT SPRINGS	CO	United States
E	241	12	26	1989	26-Dec-89	SI	Bae	Jetstream 31	EURICE		ICAO	NTSB	Bae	89/0449-0	1594	None	NPA United Express	Pasco	Washington	USA
F	131	12	26	1989	26-Dec-89	SI	BAe Jetstream 31		FSF								NPA United Express	Pasco	Washington	
I	77	12	26	1989	26-Dec-89	SI	ISH AEROSPACE-31 JETSTREAM		ICAO	89/0449-0								PASCO	UNITED STATES	
N	127	12	26	1989	26-Dec-89	SI	BAC BA-JETSTM-3101		NTSB	DCA90MA011							NPA/UNITED EXPRESS	PASCO	WA	United States
N	128	12	27	1989	27-Dec-89	SI	BEECH BE-35-V35B		NTSB	CHI90LA054							TUBBS, THOMAS A.	NORTH CANTON	OH	United States
E	242	12	28	1989	28-Dec-89	SI	Cessna	340	EURICE		ICAO	FAA	–	89/1103-0	091	–		Merrill	Wisconsin	USA
N	129	12	28	1989	28-Dec-89	SI	CESSNA CE-340-340		NTSB	CHI90FA058								MERRILL	WI	United States
N	130	12	28	1989	28-Dec-89	SI	BEECH BE-23-C24R		NTSB	CHI90FA056							37329 INC	MERRILL	WI	United States
N	131	12	29	1989	29-Dec-89	SI	PIPER PA-34-200		NTSB	CHI90LA053								JENISON	MI	United States
E	223			1989		SI	Avro	748	EURICE		CAA	–	–	Occnum 8900888H	–	–	British Airways	?	?	?
E	224			1989		SI	Bae	ATP	EURICE		CAA	–	–	Occnum 8900886J	–	–	Manx Airlines	?	?	?
W	94	1	1	1990	1-Jan-90	SI	Cessna 172		TC (Walper)	A90O0009								Marathon	Ontario	Canada
E	248	1	26	1990	26-Jan-90	SI	Mitsubishi	MU-2	EURICE		Bae	–	–	None	–	–	Great Western Aviation	Nr Meekatharra	?	Australia
F	132	1	26	1990	26-Jan-90	SI	Mitsubishi MU-2B-60		FSF								Great Western Aviation	Near Meekatharra		
E	252	1	30	1990	30-Jan-90	SI	Cessna	Caravan	EURICE		FAA	Bae	–	136	None	–	Business Air	Burlington	Vermont	USA
E	253	2	14	1990	14-Feb-90	SI	Mitsubishi	MU-2	EURICE		ICAO	NTSB	–	90/0081-0	524	–		Putnam	Texas	USA
N	27	2	14	1990	14-Feb-90	SI	MTSBSI MU-2B-60		NTSB	FTW90FA072								PUTNAM	TX	United States
N	132	2	22	1990	22-Feb-90	SI	PIPER PA-32RT-300		NTSB	CHI90FA087								LOSTANT	IL	United States
E	254	2	27	1990	27-Feb-90	SI	Cessna	Caravan	EURICE		ICAO	NTSB	Bae	90/0084-0	1579	None	PM Air	Denver	Colorado	USA
N	133	2	27	1990	27-Feb-90	SI	CESSNA CE-208-B		NTSB	DEN90FA086							P. M. AIR, INC.	DENVER	CO	United States
N	134	3	22	1990	22-Mar-90	SI	CESSNA CE-182-H		NTSB	DEN90FA076							DONALD L. MYERS	CAPUTA	SD	United States
N	135	3	24	1990	24-Mar-90	SI	CESSNA CE-172-M		NTSB	DEN90LA079								COLORADO SPRINGS	CO	United States
S	17	3		1990	Mar-90	SI	LRG		NASA	138154								DEN	CO	
E	258	4	3	1990	3-Apr-90	SI	NAMC	YS-11	EURICE		ICAO	–	–	90/1042-0	–	–		?	?	USA
I	79	4	3	1990	3-Apr-90	SI	NAMC		ICAO	90/1042-0								WEST LAFAYETTE	Indiana	USA
N	136	4	9	1990	9-Apr-90	SI	CESSNA CE-210-E		NTSB	DEN90FA089							CARL FELDHAMER & ASSOCIATE	ELBERT	CO	United States
W	83	5	7	1990	7-May-90	SI	Cessna 404		TC (Walper)	A90C0086							Athabaska Airways Ltd	Prince Albert	Saskatchewan	Canada
E	259	5	23	1990	23-May-90	SI	Fairchild	Metro	EURICE		ICAO	–	–	90/0114-0	–	–		?	?	USA
I	80	5	23	1990	23-May-90	SI	Fairchild		ICAO	90/0144-0								OLYMPIA	?	USA
S	18	5		1990	May-90	SI	HVT		NASA	145802								OSH	NE	
W	95	6	5	1990	5-Jun-90	SI	Cessna 172 M		TC (Walper)	A90Q0136								Lac Eon	Quebec	Canada
S	20	7		1990	Jul-90	SI	MLG		NASA	153598								LVS	NM	
E	257	8	21	1990	21-Aug-90	SI	Bae	125	EURICE		Bae	–	–	None	–	–		Nr Munich	Bavaria	Germany
W	99	8	22	1990	22-Aug-90	SI	Rockwell Commander 500S		TC (Walper)	A90Q0228							Les Ailes de Charlevoix Inc	Quaqtaq	Quebec	Canada
N	137	10	2	1990	2-Oct-90	SI	CESSNA CE-210-T210N		NTSB	DEN91FA002							DENVER AIR CENTER, INC.	GYPSUM	CO	United States
N	138	10	7	1990	7-Oct-90	SI	BEECH BE-35-P35		NTSB	DEN91FA006								AURORA	CO	United States
N	139	11	7	1990	7-Nov-90	SI	BEECH BE-36-A36		NTSB	NYC91FA025							JOHN FRANKLIN MALLORY	BRADFORD	PA	United States
N	140	11	20	1990	20-Nov-90	SI	PIPER PA-34-200T		NTSB	SEA91FA020							REGIONAL EXPRESS	ALBION	ID	United States
N	141	11	22	1990	22-Nov-90	SI	CESSNA CE-172-M		NTSB	NYC91FA034							AIR NATIONAL GUARD AERO IN	PERHAM	ME	United States
E	260	11	27	1990	27-Nov-90	SI	Cessna	401	EURICE		ICAO	–	–	90/0496-0	–	–		?	?	USA
E	246			1990		SI	Bae	ATP	EURICE		CAA	–	–	Occnum 9001687H	–	–		?	?	?

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E	246			1990		BI	Bae	ATP	EURICE		CAA	–	–	Docnum 9000774C	–	–		?	?	?
E	247			1990		BI	Fokker	F27	EURICE		CAA	–	–	Docnum 9000250D	–	–	Air UK	?	?	?
I	81	1	7	1991	7-Jan-91	BI	Fokker F27		ICAO	91/0174-0								HULL/HUMBERSIDE	?	UK
N	142	1	19	1991	19-Jan-91	BI	PIPER PA-28R-200		NTSB	NYC91LA081							GERALD P. HEALY	ERBURNE CENTER	VT	United States
E	269	1	23	1991	23-Jan-91	BI	Cessna	340	EURICE		ICAO	–	–	91/0171-0	–	–		?	?	Germany
E	270	1	30	1991	30-Jan-91	BI	Bae	Jetstream 31	EURICE		ICAO	NTSB	Bae	91/0031-0	478	None	US Air Express	Beckley	West Virginia	USA
F	133	1	30	1991	30-Jan-91	BI	BAe Jetstream 31		FBF								Carolina Commuter Air	Beckley	West Virginia	
I	83	1	30	1991	30-Jan-91	BI	ISH AEROSPACE-31 JETSTREAM		ICAO	91/0031-0								BECKLEY		UNITED STATES
N	17	1	30	1991	30-Jan-91	BI	BAC BA-JETSTM-3101		NTSB	DCA91MA019							CCAIR INC.	BECKLEY	WV	United States
S	22	1		1991	Jan-91	BI	LRG		NASA	167782								BTM	MT	
N	143	2	13	1991	13-Feb-91	BI	BEECH BE-33-F33A		NTSB	SEA91LA090							MAC W. HUSS	OGDEN	UT	United States
N	144	2	18	1991	18-Feb-91	BI	CESSNA CE-182-182		NTSB	NYC91LA077							GENERAL PRODUCTION INC	WALLKILL	NY	United States
N	145	2	24	1991	24-Feb-91	BI	CESSNA CE-172-N		NTSB	CHI91DCJ01							DALEN R. KNIEP	WESTERN	NE	United States
S	25	2		1991	Feb-91	BI	MLG		NASA	171138								SYR	NY	
N	146	3	1	1991	1-Mar-91	BI	BEECH BE-58-P		NTSB	LAX91FA117							JOHN G. KRISCH	GREEN VALLEY	CA	United States
N	147	3	12	1991	12-Mar-91	BI	BEECH BE-36-A36		NTSB	CHI91LA108							GROWTH MANAGEMENT CORP	OGALLALA	NE	United States
N	148	3	14	1991	14-Mar-91	BI	CESSNA CE-182-F		NTSB	BFO91FA031							THOMAS O. METCALFE, JR.	PRINCETON	WV	United States
N	149	4	2	1991	2-Apr-91	BI	PIPER PA-32-260		NTSB	NYC91FA090							RICHARD G. STUTESMAN	NAPLES	NY	United States
N	150	4	9	1991	9-Apr-91	BI	BEECH BE-33-F33A		NTSB	CHI91FA128							TRUCKALINE SUSPENSION CENTE	HIPPEWA FALLS	WI	United States
S	27	6		1991	Jun-91	BI	LRG		NASA	180210								TCC	NM	
E	275	8	11	1991	11-Aug-91	BI	ATR	42	EURICE		Bae	–	–	None	–	–		?	?	?
E	276	8	11	1991	11-Aug-91	BI	Bae	ATP	EURICE		ICAO	CAA	Bae	91/0406-0	AAR 4/92	None	British Midland Airways	Nr Cowley	Oxfordshire	UK
I	87	8	11	1991	11-Aug-91	BI	Bae ATP		ICAO	91/0406-0							British Midland Airways	Nr Cowley	Oxfordshire	UK
W	108	8	30	1991	30-Aug-91	BI	McDonnell Douglas DC-9-32		TC (Walper)	A91W0177							Air Canada	Edmonton	Alberta	Canada
E	277	10	6	1991	6-Oct-91	BI	ATR	42	EURICE		FAA	–	–	121	–	–	Simmons Airlines	Marquette	Michigan	USA
E	278	10	8	1991	8-Oct-91	BI	Embraer	Bandeirante	EURICE		NLR	–	–	None	–	–	BAC Express Airlines	Nr Frederickshabe	——	Greenland
N	151	10	14	1991	14-Oct-91	BI	BEECH BE-36-A36		NTSB	CHI92FA008							KIRVADA GENERAL, INC.	LAKEVILLE	MN	United States
N	152	10	30	1991	30-Oct-91	BI	PIPER PA-24-250		NTSB	DEN92LA008							SOUTHWEST AIRCRAFT RECOVE	ELLICOTT	CO	United States
E	280	11	22	1991	22-Nov-91	BI	Embraer	Brasilia	EURICE		ICAO	–	–	91/0801-0	–	–	Air Littoral	Clermont-Ferrand	——	France
I	88	11	22	1991	22-Nov-91	BI	Embraer-120 Brasilia		ICAO	91/0801-0							Air Littoral	Clermont-Ferrand	——	France
N	153	11	22	1991	22-Nov-91	BI	CESSNA CE-172-P		NTSB	CHI92LA033							BALDWIN AIRCRAFT	MARQUETTE	MI	United States
E	281	11	29	1991	29-Nov-91	BI	Antonov	An-24	EURICE		NLR	–	–	None	–	–	Aeroflot	Bugulma		Russian Fed
N	154	12	2	1991	2-Dec-91	BI	CESSNA CE-310-D		NTSB	FTW92LA032							HARRY G. HANSON	HAMILTON	TX	United States
I	89	12	7	1991	7-Dec-91	BI	TUPOLEV-TU-134A/B/B-1/B-3		ICAO	91/0800-0								BERLIN/SCHOENEFELD		GERMANY
E	282	12	13	1991	13-Dec-91	BI	Piper	T1040	EURICE		ICAO	–	–	91/1007-0	–	–		?	?	USA
W	105	12	29	1991	29-Dec-91	BI	Cessna 172 M		TC (Walper)	A91Q0356								Victoriaville	Quebec	Canada
W	90	12	30	1991	30-Dec-91	BI	Airbus A320-211		TC (Walper)	A91C0274							Air Canada	Winnipeg	Manitoba	Canada
N	155	12	31	1991	31-Dec-91	BI	CESSNA CE-182-K		NTSB	CHI92LA094							MARLIN J. BOWMAN	HUNTINGTON	IN	United States
S	36	12		1991	Dec-91	BI	MLG		NASA	198652								MEM	TN	
E	283			1991		BI	ATR	42	EURICE		CAA	–	–	Docnum 9103848D	–	–	Ryanair	Brecon	Wales	UK
E	284			1991		BI	Avro	748	EURICE		CAA	–	–	Docnum 9100513B	–	–	Jersey European Airlines	?	?	?
E	287			1991		BI	Saab	SF340	EURICE		CAA	–	–	Docnum 9100828D	–	–	Aer Lingus	?	?	?
E	290			1991		BI	Embraer	Brasilia	EURICE		FAA	–	–	None	–	–		Fort Smith	Arkansas	USA
N	18	1	4	1992	4-Jan-92	BI	BEECH BE-36-A36TC		NTSB	CHI92FA067							GRANDMOTHER, INC	PEKIN	IL	United States
N	156	1	29	1992	29-Jan-92	BI	CESSNA CE-182-R		NTSB	SEA92FA106							MARINEX AVIATION INC	GARRISON	MT	United States
I	90	2	2	1992	9-Feb-92	BI	ANTONOV-AN-24		ICAO	92/0244-0								Guryev AP		Kazakhstan
E	291	2	8	1992	8-Feb-92	BI	Lockheed	Neptune	EURICE		ICAO	–	–	92/0032-0	–	–	Hawkins & Powers	Dixon	Wyoming	USA
I	91	2	8	1992	8-Feb-92	BI	Lockheed SP-2H		ICAO	92/0032-0							Hawkins & Powers	Dixon	Wyoming	USA
E	292	2	9	1992	9-Feb-92	BI	Antonov	An-24	EURICE		NLR	–	–	None	–	–	Kazakhstan Airlines	Guryev	——	Kazakhstan
I	92	2	9	1992	9-Feb-92	BI	Antonov AN-24		ICAO	92/0398-0							Kazakhstan Airlines	Guryev	——	Kazakhstan
E	293	2	13	1992	13-Feb-92	BI	Cessna	Golden Eagle	EURICE		ICAO	NTSB	–	92/0034-0	263	–		Logansport	Indiana	USA
N	157	2	14	1992	14-Feb-92	BI	PIPER PA-32-301		NTSB	NYC92FA058							JAMES A. MCCAULEY	HEATH	OH	United States
N	158	2	16	1992	16-Feb-92	BI	MOONEY MOONEY-20-20		NTSB	NYC92FA061							DAVID B. & ELISABETH FRASER	WHEELING	WV	United States
N	159	3	10	1992	10-Mar-92	BI	PIPER PA-46-310P		NTSB	BFO92LA037							CHARLES HAMPTON'S A-1 SIGNS	LIMA	OH	United States
N	160	3	26	1992	26-Mar-92	BI	PIPER PA-28-236		NTSB	LAX92FA151							N V CORPORATION	LEBEC	CA	United States
N	161	3	27	1992	27-Mar-92	BI	MOONEY MOONEY-20-L		NTSB	BFO92FA048							CEPHAS W. JACKSON, JR., MO	OUNGS BOTTOM	WV	United States
S	38	5		1992	May-92	BI	MLG		NASA	211430								SHV	LA	
E	297	7	23	1992	23-Jul-92	BI	Rockwell	Commander 500	EURICE		ICAO	–	–	92/1072-0	–	–		?	?	USA
N	162	7	23	1992	23-Jul-92	BI	GULSTM GA-680-F		NTSB	DEN92FA078							MCLAUGHLIN CONSTRUCTION C	MANVILLE	WY	United States
N	163	9	17	1992	17-Sep-92	BI	PIPER PA-32RT-300T		NTSB	CHI92FA280							WEBER, TRACY T.	PULLMAN	MI	United States
N	164	10	3	1992	3-Oct-92	BI	BLANCA BL-17-31ATC		NTSB	LAX93FA004							THUNDERBIRD AIR, INC	ELKO	NV	United States
N	165	10	20	1992	20-Oct-92	BI	BEECH BE-36-A36		NTSB	NYC93FA028							ROBERT J. CARLETON	IDDLEBOURNE	WV	United States
E	298	10	28	1992	28-Oct-92	BI	Bae	ATP	EURICE		Bae	–	–	None	–	–		?	?	?
N	166	10	29	1992	29-Oct-92	BI	BEECH BE-60-D60A		NTSB	LAX93FA045							JAMES L. RICHARDS	ELY	NV	United States
N	167	11	4	1992	4-Nov-92	BI	PIPER PA-28R-180		NTSB	SEA93LA016							AERO CENTER 1, INC	EVANSTON	WY	United States
N	168	11	11	1992	11-Nov-92	BI	CESSNA CE-207-A		NTSB	ANC93LA014							STAN WREN	EKWOK	AK	United States
N	169	11	20	1992	20-Nov-92	BI	PIPER PA-32RT-300T		NTSB	DEN93FA012							KEVIN K. OPP	KERSEY	CO	United States
E	299	11	21	1992	21-Nov-92	BI	Beech	Duke	EURICE		ICAO	NTSB	–	92/1229-0	1043	–		Snoqualmie Pass	Washington	USA
N	8	11	21	1992	21-Nov-92	BI	BEECH BE-60-A60		NTSB	SEA93FA026							HUBER, JAMES D.	SNOQUALMIE	WA	United States
E	300	11	23	1992	23-Nov-92	BI	Rockwell	Commander 500	EURICE		ICAO	NTSB	–	93/0213-0	898	–	Dewey Towner	McCook	Nebraska	USA
N	170	11	23	1992	23-Nov-92	BI	GULSTM GA-500-B		NTSB	CHI93LA041							DEWEY TOWNER	MC COOK	NE	United States
N	171	11	30	1992	30-Nov-92	BI	BEECH BE-35-A36		NTSB	CHI93LA047							HOYT INVESTMENTS	FRANKFORT	IL	United States
N	172	12	22	1992	22-Dec-92	BI	CESSNA CE-150-K		NTSB	SEA93LA043							KOHUT, ROBERT J.	ORAN JUNCTION	WY	United States
E	294			1992		BI	Bae	125	EURICE		CAA	–	–	Docnum 9204110H	–	–	Falcon Jet	Palma	——	Spain
E	295			1992		BI	Bae	ATP	EURICE		CAA	–	–	Docnum 9204880D	–	–	British Airways	——	Irish Sea	UK
E	288			1992		BI	Bae	ATP	EURICE		CAA	–	–	Docnum 9200149A	–	–	Manx Airlines	?	?	?
E	289			1992		BI	Vickers	Vanguard	EURICE		CAA	–	–	Docnum 9200880D	–	–	Airbridge Carriers	?	?	?
E	312	1	2	1993	2-Jan-93	BI	Saab	SF340	EURICE		ICAO	NTSB	NLR	93/0015-0	367	None	Express Airlines	Hibbing	Minnesota	USA

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F	137	1	2	1993	2-Jan-93	SI	Saab 340A		FBF								Express I Hibbing	Hibbing	Minnesota	
I	98	1	2	1993	2-Jan-93	SI	Saab 340A		ICAO	93/0015-0							Express I Hibbing	Hibbing	Minnesota	
N	173	1	7	1993	7-Jan-93	SI	CESSNA CE-310-R		NTSB	CHI93LA066							BROWN MACHINE WORKS & SUPP	MARYSVILLE	KS	United States
E	313	1	11	1993	11-Jan-93	SI	Rockwell	Commander 500	EURICE		ICAO	NTSB	–	93/0018-0	412	–	Central Airlines	Susank	Kansas	USA
N	174	1	11	1993	11-Jan-93	SI	GULSTM GA-600-B		NTSB	CHI93LA070							CENTRAL AIRLINES, INC.	SUSANK	KS	United States
E	314	1	12	1993	12-Jan-93	SI	Bae	ATP	EURICE		Bae	–	–	None	–	–		?	?	?
W	113	1	13	1993	13-Jan-93	SI	Cessna 208 B		TC (Walper)	A93O0012							Simo Air Ltd.	Ottawa	Ontario	Canada
W	114	1	13	1993	13-Jan-93	SI	Cessna 421 C		TC (Walper)	A93O0015							Crown Mail and Delivery Services Lt	Hamilton	Ontario	Canada
E	315	1	15	1993	15-Jan-93	SI	Cessna	Golden Eagle	EURICE		ICAO	NTSB	–	93/1184-0	442	–		Reno	Nevada	USA
N	175	1	28	1993	28-Jan-93	SI	CESSNA CE-310-R		NTSB	CHI93LA077							DEWITT ENTERPRISES INC	MINOCQUA	WI	United States
E	318	3	4	1993	4-Mar-93	SI	ATR	72	EURICE		ICAO	–	–	93/0033-0	–	–		?	?	USA
I	97	3	4	1993	4-Mar-93	SI	ATR 72		ICAO	93/0033-0								?	?	USA
E	321	3	23	1993	23-Mar-93	SI	Bae	ATP	EURICE		CAA	–	–	Occnum ?	–	–		?	?	?
N	176	3	29	1993	29-Mar-93	SI	CESSNA CE-152-152		NTSB	LAX93FA166							PALO ALTO FLYING CLUB	DUNSMUIR	CA	United States
N	8	4	1	1993	1-Apr-93	SI	SWRNGN SA-227-TT		NTSB	ATL93MA066								BLOUNTVILLE	TN	United States
W	115	4	1	1993	1-Apr-93	SI	Piper PA-24-250		TC (Walper)	A93O0082								Toronto Int'l	Ontario	Canada
I	99	4	11	1993	11-Apr-93	SI	Bae ATP		ICAO	93/0066-0							Air Wisconsin	Oshkosh	Wisconsin	USA
N	177	4	12	1993	12-Apr-93	SI	PIPER PA-32R-301		NTSB	NYC93FA080							E.G. AND H. INC	LAPEER	NY	United States
E	324	4	23	1993	23-Apr-93	SI	Embraer	Brasilia	EURICE		ICAO	NTSB	Bae	93/0074-0	471	None	Continental Express	Pine Bluff	Arkansas	USA
I	100	4	29	1993	29-Apr-93	SI	EMB EMB-120-RT		ICAO	93/0074-0							CONTINENTAL EXPRESS	PINE BLUFF	AR	United States
N	178	4	29	1993	29-Apr-93	SI	EMB EMB-120-RT		NTSB	FTW93MA143							CONTINENTAL EXPRESS	PINE BLUFF	AR	United States
N	179	6	8	1993	8-Jun-93	SI	BEECH BE-35-K35		NTSB	LAX93LA244								EUREKA	NV	United States
S	47	6		1993	Jun-93	SI	LRG		NASA	243424								BDF	IL	
E	326	10	6	1993	6-Oct-93	SI	Bae	ATP	EURICE		Bae	–	–	None	–	–		?	?	?
E	327	10	7	1993	7-Oct-93	SI	Bae	ATP	EURICE		Bae	–	–	None	–	–		?	?	?
N	180	10	31	1993	31-Oct-93	SI	MOONEY MOONEY-20-K		NTSB	NYC94FA025								BLUE ASH	OH	United States
E	329	11	6	1993	6-Nov-93	SI	Cessna	Golden Eagle	EURICE		ICAO	–	–	93/0239-0	–	–		Greensburg ?	?	USA
N	181	11	6	1993	6-Nov-93	SI	CESSNA CE-421-B		NTSB	CHI94MA032							OMNI GROUP	GREENSBURG	IN	United States
N	182	11	14	1993	14-Nov-93	SI	BEECH BE-36-A36TC		NTSB	LAX94LA045								FLORENCE	AZ	United States
N	183	11	25	1993	25-Nov-93	SI	CESSNA CE-303-T303		NTSB	FTW94FA036								ROGERS	AR	United States
E	331	12	1	1993	1-Dec-93	SI	Short	330	EURICE		ICAO	NLR	–	93/0342-0	None	–	Quebec Government AS	Umiujaq	?	Canada
E	332	12	1	1993	1-Dec-93	SI	Bae	Jetstream 31	EURICE		Bae	NLR	–	None	None	–	Express Airlines	Hibbing	Minnesota	USA
I	102	12	1	1993	1-Dec-93	SI	Short 330		ICAO	93/0342-0							Quebec Government AS	Umiujaq	?	Canada
W	86	12	1	1993	1-Dec-93	SI	Shorts SD3-30 Variant 300		TC (Walper)	A93Q0245							Ministere Des Transports	Umiujak	Quebec	Canada
N	184	12	8	1993	8-Dec-93	SI	ARONCA AR-7-AC		NTSB	ANC94LA025							KENT L. SHERMAN	CIRCLE CITY	AK	United States
S	53	12		1993	Dec-93	SI	LRG		NASA	260297								LGA	NY	
E	301			1993		SI	Bae	125	EURICE		CAA	–	–	Occnum 9304016F	–	–	Bristow Helicopters	Oslo	——	Norway
E	302			1993		SI	Bae	125	EURICE		CAA	–	–	Occnum 9303598E	–	–	CAA	Honiley	Midlands	UK
E	303			1993		SI	Short	330	EURICE		CAA	–	–	Occnum 9304433X	–	–	Jersey European A/L	Leeds	Yorkshire	UK
E	304			1993		SI	Short	330	EURICE		CAA	–	–	Occnum 9304601D	–	–	Gill Air	Nr Aberdeen	Scotland	UK
E	305			1993		SI	Short	360	EURICE		CAA	–	–	Occnum 9304583B	–	–	Cityflyer	Daventry	Midlands	UK
E	306			1993		SI	Bae	ATP	EURICE		CAA	–	–	Occnum 9303577B	–	–	British Airways	Daventry	Midlands	UK
E	307			1993		SI	Bae	ATP	EURICE		CAA	–	–	Occnum 9304624C	–	–	British Airways	?	?	?
E	309			1993		SI	Bae	ATP	EURICE		CAA	–	–	Occnum 9303578D	–	–	British Airways	?	?	?
E	317			1993		SI	ATR	42	EURICE		Bae	FAA	–	None	?	–		?	New Jersey	USA
E	343	1	7	1994	7-Jan-94	SI	Bae	Jetstream 41	EURICE		Bae	NLR	–	None	None	–	Atlantic Coast Airlines	Nr Columbus	Ohio	USA
E	345	1	28	1994	28-Jan-94	SI	Cessna	Golden Eagle	EURICE		NTSB	–	–	80	–	–	Sky Harbour Air Service	McCook	Nebraska	USA
N	19	1	28	1994	28-Jan-94	SI	CESSNA CE-421-C		NTSB	CHI94MA072								MC COOK	NE	United States
E	346	1	28	1994	28-Jan-94	SI	Cessna	Golden Eagle	EURICE		ICAO	–	–	94/0212-0	–	–		?	?	Norway
N	185	2	10	1994	10-Feb-94	SI	MOONEY MOONEY-20-K		NTSB	SEA94FA060							HICKS, ROY H	APPLEGATE	OR	United States
W	120	2	13	1994	13-Feb-94	SI	Piper PA-22-108		TC (Walper)	A94O0043								Grimsby Air Park	Ontario	Canada
E	348	2	24	1994	24-Feb-94	SI	Antonov	An-12	EURICE		ICAO	NLR	–	94/0039-0	None	–	N W Air Trans Dir	Nalchik	——	Russian Fed
F	139	2	24	1994	24-Feb-94	SI	Vickers Viscount 813		FBF								British World Airways Near	Uttoxeter		
F	140	2	24	1994	24-Feb-94	SI	Antonov An-12		FBF								North Western Air Transport Direction	Nalchik		
I	106	2	24	1994	24-Feb-94	SI	Vickers Viscount 813		ICAO	94/0015-0							British World Airways Near	Uttoxeter	Staffordshire	UK
I	107	2	24	1994	24-Feb-94	SI	Antonov AN-24		ICAO	94/0039-0							N W Air Trans Dir	Nalchik	——	Russian Fed
E	350	3	2	1994	2-Mar-94	SI	McDonnell-Douglas	MD-80	EURICE		NLR	–	–	None	–	–	Continental Airlines	New York	New York	USA
E	351	3	3	1994	3-Mar-94	SI	Cessna	340	EURICE		ICAO	–	–	94/0031-0	–	–		?	?	USA
N	186	3	3	1994	3-Mar-94	SI	CESSNA CE-340-340		NTSB	NYC94FA052							JAMES FLYING SERVICE INC	WESTHAMPTON	NY	United States
N	187	3	13	1994	13-Mar-94	SI	PIPER PA-32RT-300		NTSB	CHI94LA104								HARBOR SPRINGS	MI	United States
N	188	3	19	1994	19-Mar-94	SI	CESSNA CE-175-175		NTSB	LAX94LA169								CURRIE	NV	United States
N	189	4	8	1994	8-Apr-94	SI	PIPER PA-32RT-300		NTSB	ATL94FA075							TENNESSEE AIR CORP INC.	SMITHVILLE	TN	United States
N	190	4	24	1994	24-Apr-94	SI	PIPER PA-32-260		NTSB	SEA94FA106								KELLOGG	ID	United States
S	58	7		1994	Jul-94	SI	MLG		NASA	276628								MLB	FL	
E	354	8	9	1994	9-Aug-94	SI	Piper	Seneca	EURICE		NTSB	–	–	1008	–	–	P & N Corporation	Marion	Iowa	USA
N	191	10	3	1994	3-Oct-94	SI	CESSNA CE-337-T337G		NTSB	FTW95FA008							WALKER, LAUREN E	MILFORD	UT	United States
N	192	10	5	1994	5-Oct-94	SI	GULSTM GA-680-680		NTSB	LAX95FA003								ESSEX	CA	United States
E	361	10	19	1994	19-Oct-94	SI	Embraer	Brasilia	EURICE		FAA	–	–	None	–	–	Skywest Airlines	Elko	Nevada	USA
E	366	10	29	1994	29-Oct-94	SI	Antonov	AN-12	EURICE		NLR	–	–	None	–	–	Aero Nika	Ust-Ilimsk	——	Russian Fed
E	367	10	31	1994	31-Oct-94	SI	ATR	72	EURICE		NLR	–	–	None	–	–	Simmons Airlines	Roselawn	Indiana	USA
F	141	10	31	1994	31-Oct-94	SI	ATR-72-212		FBF								American Eagle	Roselawn	Indiana	
I	111	10	31	1994	31-Oct-94	SI	DE TRANSPORT REGIONAL -ATR 72		ICAO	94/0344-0								ROSELAWN	UNITED STATES	
N	20	10	31	1994	31-Oct-94	SI	AEROSP ATR-72-212		NTSB	DCA95MA001								ROSELAWN	IN	United States
N	193	11	18	1994	18-Nov-94	SI	PIPER PA-32-300		NTSB	LAX95FA282							STEPHEN M. MUMFORD	FLAGSTAFF	AZ	United States
N	194	11	26	1994	26-Nov-94	SI	PIPER PA-44-180		NTSB	CHI95LA046								DICKINSON	ND	United States
E	368	12	8	1994	8-Dec-94	SI	Beech	18	EURICE		ICAO	NTSB	–	94/0422-0	1985	–	Cape Central Airways	Kansas City	Missouri	USA
N	10	12	8	1994	8-Dec-94	SI	BEECH BE-18-E18S		NTSB	CHI95LA053								KANSAS CITY	MO	United States
W	136	12	9	1994	9-Dec-94	SI	ATR-42-300		TC (Walper)	A94Q0223							Inter-Canadien	Dorval	Quebec	Canada

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N	195	12	10	1994	10-Dec-94	BI	PIPER PA-32RT-300		NTSB	MIA95FA037							AIR CARRIERS, INC	SYLVAN SPRINGS	AL	United States
W	130	12	19	1994	19-Dec-94	BI	Mooney M-20K		TC (Walper)	A94P0296								Enderby	British Columbia	Canada
N	196	12	31	1994	31-Dec-94	BI	CESSNA CE-310-Q		NTSB	FTW95LA078								GUTHRIE	OK	United States
B	61	12		1994	Dec-94	BI	MLG		NASA	290480								MMZT	FO	
B	62	12		1994	Dec-94	BI	MLG		NASA	290769								SFO	CA	
E	334			1994		BI	Short	360	EURICE		CAA	–	–	Occnum 9400188C	–	–	GB Air	Stansted	Essex	UK
E	335			1994		BI	Bae	ATP	EURICE		CAA	–	–	Occnum 9401322E	–	–	Manx Airlines	Isle of Man	Irish Sea	UK
E	337			1994		BI	Bae	ATP	EURICE		Bae	–	–	None	–	–		?	?	?
E	338			1994		BI	Bae	ATP	EURICE		CAA	Bae	–	Occnum 9400391B	None	–		?	?	?
E	347			1994		BI	Saab	SF340	EURICE		CAA	–	–	Occnum 9401114A	–	–	Business Air	Pole Hill	Midlands ?	UK
N	21	1	16	1995	16-Jan-95	BI	CESSNA CE-310-Q		NTSB	SFO95LA027							GORDON AIR MANAGEMENT	CLARION	PA	United States
E	379	1	19	1995	19-Jan-95	BI	Rockwell/DASA	X-31	EURICE		Bae	–	–	None	–	–	USAF	Edwards AFB	California	USA
E	380	1	20	1995	20-Jan-95	BI	Cessna	Golden Eagle	EURICE		ICAO	–	–	95/1011-0	–	–		?	?	USA
W	136	1	21	1995	21-Jan-95	BI	Cessna 172		TC (Walper)	A95C0011								Rosetown	Saskatchewan	Canada
N	197	2	5	1995	5-Feb-95	BI	CESSNA CE-310-L		NTSB	CHI95FA082								VALPARAISO	IN	United States
N	198	2	8	1995	8-Feb-95	BI	CESSNA CE-177-RG		NTSB	FTW95FA111								LARKSPUR	CO	United States
N	199	2	12	1995	12-Feb-95	BI	GULSTM GA-690-A		NTSB	FTW95FA114								GUTHRIE	OK	United States
N	200	2	14	1995	14-Feb-95	BI	PIPER PA-46-310P		NTSB	NYC95FA066								CHIPPEWA FALLS	WI	United States
E	381	2	16	1995	16-Feb-95	BI	Piper	Aztec	EURICE		NTSB	–	–	180	–	–	AB Flight Services	Minneapolis	Minnesota	USA
N	201	2	16	1995	16-Feb-95	BI	PIPER PA-23-250		NTSB	CHI95LA086							AB FLIGHT SERVICES	MINNEAPOLIS	MN	United States
E	382	3	2	1995	2-Mar-95	BI	Cessna	Caravan	EURICE		Bae	–	–	None	–	–	Martinaire	Ardmore	Oklahoma	USA
F	142	3	2	1995	2-Mar-95	BI	Cessna 208B		F&F								Martinaire	Ardmore	Oklahoma	
N	202	3	2	1995	2-Mar-95	BI	CESSNA CE-208-B		NTSB	FTW95FA129							MARTINAIRE INC	ARDMORE	OK	United States
I	113	3	3	1995	3-Mar-95	BI	ISRAEL-IAI-1125		ICAO	95/0229-0								GILLETTE	UNITED STATES	
I	114	3	4	1995	4-Mar-95	BI	DE TRANSPORT REGIONAL-ATR 42		ICAO	95/0101-0								LAS VEGAS	UNITED STATES	
N	203	3	5	1995	5-Mar-95	BI	CESSNA CE-421-C		NTSB	FTW95FA130								EL PRADO	NM	United States
W	142	3	8	1995	8-Mar-95	BI	DeHavilland DHC-8-301		TC (Walper)	A95P0046							Canadian Regional	Vancouver	British Columbia	Canada
E	386	3	9	1995	9-Mar-95	BI	de Havilland Canada	Dash 8	EURICE		Trans Can	–	–	A95P0047	–	–		Vancouver	British Columbia	Canada
I	115	3	9	1995	9-Mar-95	BI	DeHavilland DHC-8-102		ICAO	95/2108-0							Canadian Regional	Vancouver	British Columbia	Canada
W	143	3	9	1995	9-Mar-95	BI	DeHavilland DHC-8-102		TC (Walper)	A95P0047							Canadian Regional	Vancouver	British Columbia	Canada
B	72	3		1995	Mar-95	BI	MLG		NASA	290239								SLC	UT	
E	383	4	3	1995	3-Apr-95	BI	ATR	42	EURICE		FAA	–	–	121	–	–	Simmons Airlines	Las Vegas	Nevada	USA
N	204	4	8	1995	8-Apr-95	BI	PIPER PA-28R-180		NTSB	LAX95FA157							S & S FLIGHT CENTER	POLLACK PINES	CA	United States
N	22	4	12	1995	12-Apr-95	BI	CESSNA CE-210-P210N		NTSB	CHI95FA121								BELLE PLAINE	MN	United States
N	205	4	16	1995	16-Apr-95	BI	CESSNA CE-172-L		NTSB	SEA95LA080								WHEATLAND	WY	United States
B	74	4		1995	Apr-95	BI	MLG		NASA	301406								SGF	MO	
N	206	5	7	1995	7-May-95	BI	CESSNA CE-210-T210L		NTSB	SEA95FA095								MILFORD	UT	United States
B	77	5		1995	May-95	BI	MLG		NASA	303787								GCC	WY	
B	78	5		1995	May-95	BI	MLG		NASA	304950								SPS	TX	
N	207	6	14	1995	14-Jun-95	BI	PIPER PA-31P-350		NTSB	SFO95FA084								CEDAR BLUFF	VA	United States
E	384	8	3	1995	3-Aug-95	BI	de Havilland Canada	Dash 8	EURICE		Trans Can	–	–	A95P0048	–	–		Vancouver	British Columbia	Canada
N	208	8	15	1995	15-Aug-95	BI	BEECH BE-60-B60		NTSB	CHI95LA298								SALINA	KS	United States
B	83	8		1995	Aug-95	BI	MLG		NASA	312478								TUL	OK	
N	209	10	16	1995	16-Oct-95	BI	PIPER PA-32RT-300		NTSB	NYC96LA013								HONESDALE	PA	United States
N	210	10	21	1995	21-Oct-95	BI	CESSNA CE-421-C		NTSB	CHI96FA017								BATTLE CREEK	MI	United States
U	1	10	31	1995	31-Oct-95	BI	ATR-42		URP	51031-IND[illegible]-1030								IND		United States
U	2	11	7	1995	7-Nov-95	BI	ATR-42		URP	51107-LVZ120030-2112								LVZ		United States
U	3	11	10	1995	10-Nov-95	BI	ATR-42		URP	51110-RFD090020-1016								RFD		United States
U	4	11	21	1995	21-Nov-95	BI	ATR-42		URP	51121-[illegible]-1300								MCO		United States
N	211	11	28	1995	28-Nov-95	BI	CESSNA CE-172-N		NTSB	CHI96LA039								STEVENS POINT	WI	United States
W	137	11	29	1995	29-Nov-95	BI	Canadair CL-600-2B19		TC (Walper)	A95A0206							Air Canada	Yarmouth	Nova Scotia	Canada
N	212	12	16	1995	16-Dec-95	BI	CESSNA CE-206-U206G		NTSB	NYC96LA041								BANGOR	ME	United States
U	5	12	18	1995	18-Dec-95	BI	ATR-42		URP	51218-CVG010035-1412								CVG		United States
U	6	12	18	1995	18-Dec-95	BI	ATR-42		URP	51218-VWV270045-1416								VWV		United States
U	7	12	18	1995	18-Dec-95	BI	ATR-42		URP	51218-ORD010030-0821								ORD		United States
N	213	12	19	1995	19-Dec-95	BI	PIPER PA-32-301		NTSB	MIA96FA048								MEMPHIS	TN	United States
U	8	12	26	1995	26-Dec-95	BI	ATR-42		URP	51226-DMB360005-0414								DMB		United States
U	9	12	26	1995	26-Dec-95	BI	ATR-42		URP	51226-ORD010040-0415								ORD		United States
I	116	12	30	1995	30-Dec-95	BI	CESSNA CE-500-560		ICAO	95/0448-0								EAGLE RIVER	WI	United States
N	214	12	30	1995	30-Dec-95	BI	CESSNA CE-500-560		NTSB	CHI96FA057								EAGLE RIVER	WI	United States
E	361			1995		BI	Short	330	EURICE		CAA	–	–	Occnum 9504969X	–	–	GB Air	Aberdeen	Scotland	UK
E	362			1995		BI	ATR	72	EURICE		CAA	–	–	Occnum ?	–	–	Cityflyer	Nr Cheltenham	Gloucestershire	UK
E	363			1995		BI	Boeing	747	EURICE		CAA	–	–	Occnum 9500622B	–	–	British Airways	New York	New York	USA
E	364			1995		BI	Bae	ATP	EURICE		CAA	–	–	Occnum 9504815D	–	–	British Airways	Aberdeen	Scotland	UK
E	365			1995		BI	Bae	ATP	EURICE		CAA	–	–	Occnum 9500780A	–	–	British Airways	Glasgow	Scotland	UK
E	366			1995		BI	Bae	ATP	EURICE		CAA	–	–	Occnum 9501806J	–	–	Manx Airlines	?	?	?
E	367			1995		BI	Bae	ATP	EURICE		CAA	–	–	Occnum 9502002X	–	–	British Airways	Kirkwall	Scotland	UK
E	368			1995		BI	de Havilland Canada	Dash 7	EURICE		CAA	–	–	Occnum 9500133F	–	–	Brymon Airways	?	?	?
E	372			1995		BI	Bae	Jetstream 41	EURICE		CAA	–	–	Occnum 9500602X	–	–	Manx Airlines	Nr Bristol	Avon	UK
E	374			1995		BI	Saab	SF340	EURICE		CAA	–	–	Occnum 9505102C	–	–	Business Air	Manchester	——	UK
E	375			1995		BI	Saab	SF340	EURICE		CAA	–	–	Occnum 9500275X	–	–	Business Air	?	?	?
E	390			1995		BI	Embraer	Brasilia	EURICE		FAA	–	–	None	–	–		Tallahassee	Florida	USA
I	119	1	2	1996	2-Jan-96	BI	CESSNA-560 CITATION V		ICAO	96/0013-0							AUGSBURG/MUEHLHAUSEN		GERMANY	
U	10	1	2	1996	2-Jan-96	BI	SD3-60		URP	60102-BIL30306912								BIL		United States
U	11	1	2	1996	2-Jan-96	BI	SF-340		URP	60201-CVG18001503								CVG		United States
U	12	1	2	1996	2-Jan-96	BI	ATR-42		URP	60102-ROD3200251114								ROD		United States
N	23	1	9	1996	9-Jan-96	BI	PIPER PA-34-200T		NTSB	CHI96LA066								DES MOINES	IA	United States
N	24	1	15	1996	15-Jan-96	BI	MTSBSI MU-2B-36A		NTSB	SEA96MA043							PRO AIR SERVICES OF SALT LAK	MALAD CITY	ID	United States

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U	13	1	16	1986	16-Jan-86	BI	SF-340		URP	60116-BBV36000203								BBV		United States
N	215	1	18	1986	18-Jan-86	BI	PIPER PA-32R-300		NTSB	MIA86LA069								SMITHVILLE	TN	United States
U	14	1	18	1986	18-Jan-86	BI	ATR-42		URP	60118-EON1220041417								EON		United States
N	216	1	27	1986	27-Jan-86	BI	PIPER PA-60-601		NTSB	BFO86LA040							GRAND AIR EXPRESS	MOUNT STORM	WV	United States
I	120	2	7	1986	7-Feb-86	BI	BEECH-1900		ICAO	86/1020-0								BRADFORD		UNITED STATES
W	140	2	11	1986	11-Feb-86	BI	Dornier GMBH 28A1		TC (Walper)	A86A0020								Goose Bay	Newfoundland	Canada
N	217	3	5	1986	5-Mar-86	BI	CESSNA CE-172-M		NTSB	CHI86LA103								VALPARAISO	IN	United States
N	218	3	7	1986	7-Mar-86	BI	BEECH BE-23-C24R		NTSB	NYC86LA071							ROBERT W. SCHMELZER	PHILADELPHIA	PA	United States
N	219	3	7	1986	7-Mar-86	BI	PIPER PA-24-250		NTSB	ATL86LA058								LIVINGSTON	TN	United States
N	220	4	16	1986	16-Apr-86	BI			NTSB	IAD86LA083								ROCKY MOUNT	VA	United States
U	15	4	20	1986	20-Apr-86	BI	ATR-42		URP	60420-JVL2500291018								JVL		United States
W	163	5	14	1986	14-May-86	BI	Cessna 206		TC (Walper)	A86W0080								Dominion Airstrip	Yukon	Canada
F	143	5	29	1986	29-May-86	BI	BAe 146		FBF								Air Wisconsin	Des Moines	Iowa	
I	121	5	29	1986	29-May-86	BI	BAe 146		ICAO	86/0254-0							Air Wisconsin	Des Moines	Iowa	
N	221	6	2	1986	2-Jun-86	BI	PIPER PA-46-310P		NTSB	CHI86FA184								AITKIN	MN	United States
U	16	9	29	1986	29-Sep-86	BI	ATR-42		URP	6-0929-BBN30002510								BBN		United States
W	183	11	5	1986	5-Nov-86	BI	Cessna 208 B		TC (Walper)	A86C0243							Air Georgian	Thunder Bay	Ontario	Canada
W	185	11	8	1986	8-Nov-86	BI	Robinson R22 Beta		TC (Walper)	A86W0212							Aerial Recon Surveys Ltd	High Level	Alberta	Canada
W	186	11	14	1986	14-Nov-86	BI	Convair 580		TC (Walper)	A86W0219							Kelowna Flightcraft	Edmonton	Alberta	Canada
N	11	11	19	1986	19-Nov-86	BI	CESSNA CE-421-B		NTSB	SEA87LA030							CROSSINGS AVIATION	OLYMPIA	WA	United States
W	162	11	22	1986	22-Nov-86	BI	Britten Norman BN-2A-8		TC (Walper)	A86Q0195							Grondair	LG-4	Quebec	Canada
U	17	11	24	1986	24-Nov-86	BI	ATR-42		URP	6-1124-TUL88800602								TUL		United States
U	18	11	24	1986	24-Nov-86	BI	ATR-42		URP	6-1124-DFW34500700								DFW		United States
W	168	12	2	1986	2-Dec-86	BI	DeHavilland DHC-6-102		TC (Walper)	A86P0279							Air BC Ltd	Kelowna	British Columbia	Canada
N	222	12	6	1986	6-Dec-86	BI	BEECH BE-58-E58		NTSB	CHI87LA040								PARK RAPIDS	MN	United States
N	223	12	8	1986	8-Dec-86	BI	LAKE LA-4-4		NTSB	NYC87LA027								GALLIPOLIS	OH	United States
W	189	12	24	1986	24-Dec-86	BI	Boeing 737-200		TC (Walper)	A86P0301							Canadian Airlines International	Vancouver	British Columbia	Canada
W	164	12	26	1986	26-Dec-86	BI	Boeing 727		TC (Walper)	A86C0277							Kelowna Flightcraft	Winnipeg	Manitoba	Canada
W	190	12	28	1986	28-Dec-86	BI	Boeing 737-200		TC (Walper)	A86P0303							Canadian Airlines International	Vancouver	British Columbia	Canada
N	25	12	28	1986	28-Dec-86	BI	BEECH BE-60-C6		NTSB	CHI87FA047								RHINELANDER	WI	United States
U	19	12	31	1986	31-Dec-86	BI	ATR-42		URP	6-1231-ORD040007-07								ORD		United States
I	123	1	3	1987	3-Jan-87	BI	SHORT-330		ICAO	87/0089-0								LIVERPOOL A/P		UNITED KINGDOM
U	20	1	3	1987	3-Jan-87	BI	ATR-42		URP	7-0103-JVL280015-17								JVL		United States
E	392	1	9	1987	9-Jan-87	BI	Embraer	Brasilia	EURICE		FAA	–	–	None	–	–	Comair	Nr Detroit	Michigan	USA
E	393	1	15	1987	15-Jan-87	BI	Mitsubishi	MU-2	EURICE		Flight	–	–	None	–	–	Pro Air Services	Nr Malad City	Idaho	USA
U	21	1	31	1987	31-Jan-87	BI	ATR-72		URP	7-0131-CGT1800078								CGT		United States
E	394	2	19	1987	19-Feb-87	BI	Cessna	Citation II	EURICE		Flight	–	–	None	–	–	Private Wings	Salzburg	—	Austria
U	22	2	20	1987	20-Feb-87	BI	ATR-42		URP	7-0220-CGT180080-16								CGT		United States
N	224	2	21	1987	21-Feb-87	BI	MAULE M-6-180C		NTSB	SEA87LA083								JORDAN VALLEY	OR	United States
U	23	2	21	1987	21-Feb-87	BI	ATR-42		URP	7-0221-CGT115030-16								CGT		United States
E	399	3	4	1987	4-Mar-87	BI	Cessna	Caravan	EURICE		Flight	–	–	None	–	–	Air Georgian	Barrie-Orillia	Ontario	Canada
W	175	3	4	1987	4-Mar-87	BI	Cessna 208 B		TC (Walper)	A87O0032							Simo Air Ltd	Barrie-Orillia	Ontario	Canada
W	184	3	18	1987	18-Mar-87	BI	Piper PA-31-350		TC (Walper)	A87W0047							Morgan Air Services Ltd	High Level	Alberta	Canada
U	24	5	4	1987	4-May-87	BI	ATR-42		URP	7-0504-ORD208086								ORD		United States
W	171	5	20	1987	20-May-87	BI	Fokker F-28 MK 1000		TC (Walper)	A87C0086							Canadian Regional	Winnipeg	Manitoba	Canada
W	178	11	25	1987	25-Nov-87	BI	Cessna 208 B		TC (Walper)	A87O0247							Air Georgian	North Bay	Ontario	Canada
W	174	12	4	1987	4-Dec-87	BI	Beech 99		TC (Walper)	A87C0232							Bearskin Lake Air Service Ltd	Webequie	Ontario	Canada
E	398	12	9	1987	9-Dec-87	BI	Embraer	Bandeirante	EURICE		Flight	–	–	None	–	–	Sowind Air	Little Grand Rapids	Manitoba	Canada
W	180	12	11	1987	11-Dec-87	BI	Swearingen SA-226TC		TC (Walper)	A87P0346							Peace River A.S. Ltd	Prince George	British Columbia	Canada
U	25	12	23	1987	23-Dec-87	BI	SAAB-340B		URP	7-1223-BYPO2019016								BYP		United States
U	29	1	6	1988	6-Jan-88	BI	SAAB-340B		URP	8-0106-AUW2800177								AUW		United States
F	64	1	30	1972	30-Jan-72	UN	Douglas DC-3		FBF								Douglas Aircraft Company	Boyne Falls	Michigan	
I	4	1	30	1972	30-Jan-72	UN	Douglas DC-3		ICAO	72/1258-0							Douglas Inc	Boyne Falls	Michigan	USA
W	217	1	8	1977	8-Jan-77	UN	Piper PA-12		TC (Icing)	A77P4002								Widgeon Lake	British Columbia	Canada
W	211	1	9	1977	9-Jan-77	UN	Stinson 108		TC (Icing)	A77O4002								Kramer Intl	Ontario	Canada
W	227	1	18	1977	18-Jan-77	UN	rth American Commander 681B		TC (Icing)	A77W4011							Associated Helicopters Ltd	Namao	Alberta	Canada
W	212	1	22	1977	22-Jan-77	UN	Aeronca 7DC		TC (Icing)	A77O4009								Rainy Lake	Ontario	Canada
W	220	1	25	1977	25-Jan-77	UN	Taylorcraft BC-12D-4-85		TC (Icing)	A77W0007								Watson Lake	Yukon	Canada
W	203	2	12	1977	12-Feb-77	UN	Cessna 150 K		TC (Icing)	A77O0015								Lefroy	Ontario	Canada
W	213	2	17	1977	17-Feb-77	UN	Unknown		TC (Icing)	A77O4118								Mississauga	Ontario	Canada
W	204	3	9	1977	9-Mar-77	UN	Aeronca 11CC		TC (Icing)	A77O0020								North Bay	Ontario	Canada
W	206	3	16	1977	16-Mar-77	UN	Aeronca 7DC		TC (Icing)	A77O0022								Bells Corners	Ontario	Canada
W	208	3	26	1977	26-Mar-77	UN	Piper PA-12		TC (Icing)	A77O0028								Whitewater Lake	Ontario	Canada
W	193	4	6	1977	6-Apr-77	UN	Cessna 150 F		TC (Icing)	A77C0033								North Battleford	Saskatchewan	Canada
W	197	4	21	1977	21-Apr-77	UN	Cessna 180 J		TC (Icing)	A77C4036							C & M Airways	Hay Lake	Saskatchewan	Canada
W	228	4	21	1977	21-Apr-77	UN	Cessna 180 J		TC (Icing)	A77W4031							C & M Airways	Buffalo Narrows	Saskatchewan	Canada
W	222	5	9	1977	9-May-77	UN	Cessna 185		TC (Icing)	A77W0044							Ediline Aviation Ltd	Brackett Lake	N.W.T.	Canada
W	218	8	17	1977	17-Aug-77	UN	McDonnell Douglas DC-8-63		TC (Icing)	A77P4064								Vancouver	British Columbia	Canada
W	198	11	26	1977	26-Nov-77	UN	Cessna 185		TC (Icing)	A77C4083							Ignace Airways Ltd	Kasch Lake	Ontario	Canada
W	199	12	7	1977	7-Dec-77	UN	Piper J-3C-65		TC (Icing)	A77C4077								Lower Manitou	Ontario	Canada
W	200	12	7	1977	7-Dec-77	UN	Piper J-3C-65		TC (Icing)	A77C4080								Lower Manitou	Ontario	Canada
W	229	12	17	1977	17-Dec-77	UN	Cessna 188		TC (Icing)	A77W4124								Atlin Lake	British Columbia	Canada
I	23	5	9	1978	9-May-78	UN	MCDONNELL-DOUGLAS-DC-10		ICAO	78/1380-0								ANCHORAGE		UNITED STATES
W	56	1	8	1986	8-Jan-86	UN	DeHavilland DHC-2 MK I		TC (Walper)	A86H0001							RCMP	Wollaston Lake	Saskatchewan	Canada
E	187	3	5	1986	5-Mar-86	UN	Mitsubishi	MU-2	EURICE		ICAO	–	–	86/0067-0	–	–		?	?	USA
W	66	5	23	1987	23-May-87	UN	Bell-Aviation B-68		TC (Walper)	A87O0038							Toronto Helicopters Ltd	Manitouwadge Lake	Ontario	Canada
S	3	3		1986	Mar-86	UN	LRG		NASA	84583								SEA	WA	
S	4	4		1986	Apr-86	UN	LRG		NASA	86174								DCA	DC	

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S	5	5		1988	May-88	UN	MLG		NASA	87200								BUF	NY	
S	6	5		1988	May-88	UN	MLG		NASA	87326								BUF	NY	
S	7	7		1988	Jul-88	UN	LRG		NASA	91340								AVP	PA	
S	8	7		1988	Jul-88	UN	MLG		NASA	91519								ENO	DE	
S	9	8		1988	Aug-88	UN	MLG		NASA	93436								LAX	CA	
S	11	4		1989	Apr-89	UN	WDB		NASA	106752								LRP	PA	
S	12	7		1989	Jul-89	UN	LRG		NASA	116474								DEN	CO	
W	67	11	8	1989	8-Nov-89	UN	Rockwell Commander 681		TC (Walper)	A89C0213							Ministic Air Ltd	Island lake	Manitoba	Canada
S	16	11		1989	Nov-89	UN	MLG		NASA	126386								RBV	NJ	
W	69	12	4	1989	4-Dec-89	UN	North American Commander 500		TC (Walper)	A89C0225							Ministic Air Ltd	Red Sucker Lake	Manitoba	Canada
W	71	1	8	1990	8-Jan-90	UN	Beech 100		TC (Walper)	A90C0005							Voyageur Airways Ltd	Sioux Lookout	Ontario	Canada
S	18	1		1990	Jan-90	UN	LRG		NASA	130882								LGA	NY	
S	19	5		1990	May-90	UN	MLG		NASA	145080								PSK	VA	
S	21	8		1990	Aug-90	UN	MLG		NASA	154273								IAH	TX	
S	23	2		1991	Feb-91	UN	MLG		NASA	169816								IAH	TX	
S	24	2		1991	Feb-91	UN	MLG		NASA	170804								DKK	NY	
S	26	5		1991	May-91	UN	MLG		NASA	179709								ORF	VA	
S	28	6		1991	Jun-91	UN	MLG		NASA	181724								FMN	NM	
S	29	7		1991	Jul-91	UN	WDB		NASA	182512								EWR	NJ	
S	30	8		1991	Aug-91	UN	WDB		NASA	187675								ZNY	NY	
W	76	10	26	1991	26-Oct-91	UN	Piper PA-12		TC (Walper)	A91P0232								Brothers	British Columbia	Canada
S	31	10		1991	Oct-91	UN	MLG		NASA	189946								MKE	WI	
S	33	11		1991	Nov-91	UN	WDB		NASA	193584								CAI	FO	
S	34	11		1991	Nov-91	UN	MLG		NASA	195280								SLT	PA	
W	82	1	18	1992	18-Jan-92	UN	McDonnell Douglas DC-9-32		TC (Walper)	A92O0013							Air Canada	Toronto	Ontario	Canada
W	81	2	6	1992	6-Feb-92	UN	Beech D18S		TC (Walper)	A92C0020							Ministic Air Ltd	Little Grand Rapids	Manitoba	Canada
S	36	5		1992	May-92	UN	MLG		NASA	208814								CVG	OH	
S	37	5		1992	May-92	UN	LRG		NASA	210837								FST	TX	
S	39	7		1992	Jul-92	UN	MLG		NASA	217233								SAX	NJ	
S	40	8		1992	Aug-92	UN	MLG		NASA	218807								PVD	RI	
S	41	8		1992	Aug-92	UN	MLG		NASA	219487								LHY	PA	
S	42	12		1992	Dec-92	UN	MLG		NASA	228039								CRW	WV	
S	43	12		1992	Dec-92	UN	MLG		NASA	230164								ORW	CT	
S	45	2		1993	Feb-93	UN	MLG		NASA	234871								YYZ	ON	Canada
S	46	2		1993	Feb-93	UN	MLG		NASA	236080								PIE	FL	
S	48	7		1993	Jul-93	UN	MLG		NASA	245880								FAK	VA	
S	49	9		1993	Sep-93	UN	MLG		NASA	252881								ORL	FO	
S	50	12		1993	Dec-93	UN	MLG		NASA	258519								IDA	ID	
S	52	12		1993	Dec-93	UN	LRG		NASA	258807								STL	MO	
S	55	1		1994	Jan-94	UN	WDB		NASA	261823								JFK	NY	
S	56	4		1994	Apr-94	UN	MLG		NASA	266486								MKC	MO	
S	57	6		1994	Jun-94	UN	LRG		NASA	273710								AML	VA	
S	60	9		1994	Sep-94	UN	LRG		NASA	284085								MIA	FL	
S	63	12		1994	Dec-94	UN	MLG		NASA	291348								RMG	GA	
E	377	1	11	1995	11-Jan-95	UN	Cessna	Caravan	EURICE		See	–	–	None	–	–		?	Arizona	USA
S	65	1		1995	Jan-95	UN	MLG		NASA	294288								ORD	IL	
S	66	1		1995	Jan-95	UN	MLG		NASA	294539								ARD	PA	
S	67	2		1995	Feb-95	UN	MLG		NASA	297704								DTW	MI	
S	68	3		1995	Mar-95	UN	MLG		NASA	297931								HSV	AL	
S	69	3		1995	Mar-95	UN	WDB		NASA	298308								ANC	AK	
S	70	3		1995	Mar-95	UN	MLG		NASA	298643								RCA	SD	
S	71	3		1995	Mar-95	UN	LRG		NASA	298571								CLE	OH	
S	73	3		1995	Mar-95	UN	MLG		NASA	300735								CLE	OH	
S	75	4		1995	Apr-95	UN	MLG		NASA	302480								ROD	OH	
S	76	5		1995	May-95	UN	LRG		NASA	303200								OTT	MD	
S	79	5		1995	May-95	UN	MLG		NASA	304880								CRW	WV	
S	80	5		1995	May-95	UN	MLG		NASA	306026								SPS	TX	
S	81	5		1995	May-95	UN	MLG		NASA	306301								FLO	SC	
S	82	7		1995	Jul-95	UN	LRG		NASA	308783								HGR	MD	
W	86	9	20	1995	20-Sep-95	UN	DeHavilland DHC-3		TC (Walper)	A95C0210							Walsten Air Services	Selwyn Lake	Ontario	Canada
S	84	12		1995	Dec-95	UN	MLG		NASA	323880								SLC	UT	
E	370			1996		UN	Bae	Jetstream 31	EURICE		CAA	–	–	Occnum 9500860H	–	–	Maersk Air	Birmingham	Midlands	UK
S	85	1		1996	Jan-96	UN	MLG		NASA	326516								DTW	MI	
S	86	1		1996	Jan-96	UN	LRG		NASA	327296								VNY	CA	
E	401	1	10	1997	10-Jan-97	UN	Beech	1900	EURICE		Flight	–	–	None	–	–	FloridaGulf Airlines	Bangor	Maine	USA
W	180	1	21	1997	21-Jan-97	UN	Beech A100		TC (Walper)	A97C0013							Bearskin Lake Air Service Ltd	Dryden	Ontario	Canada

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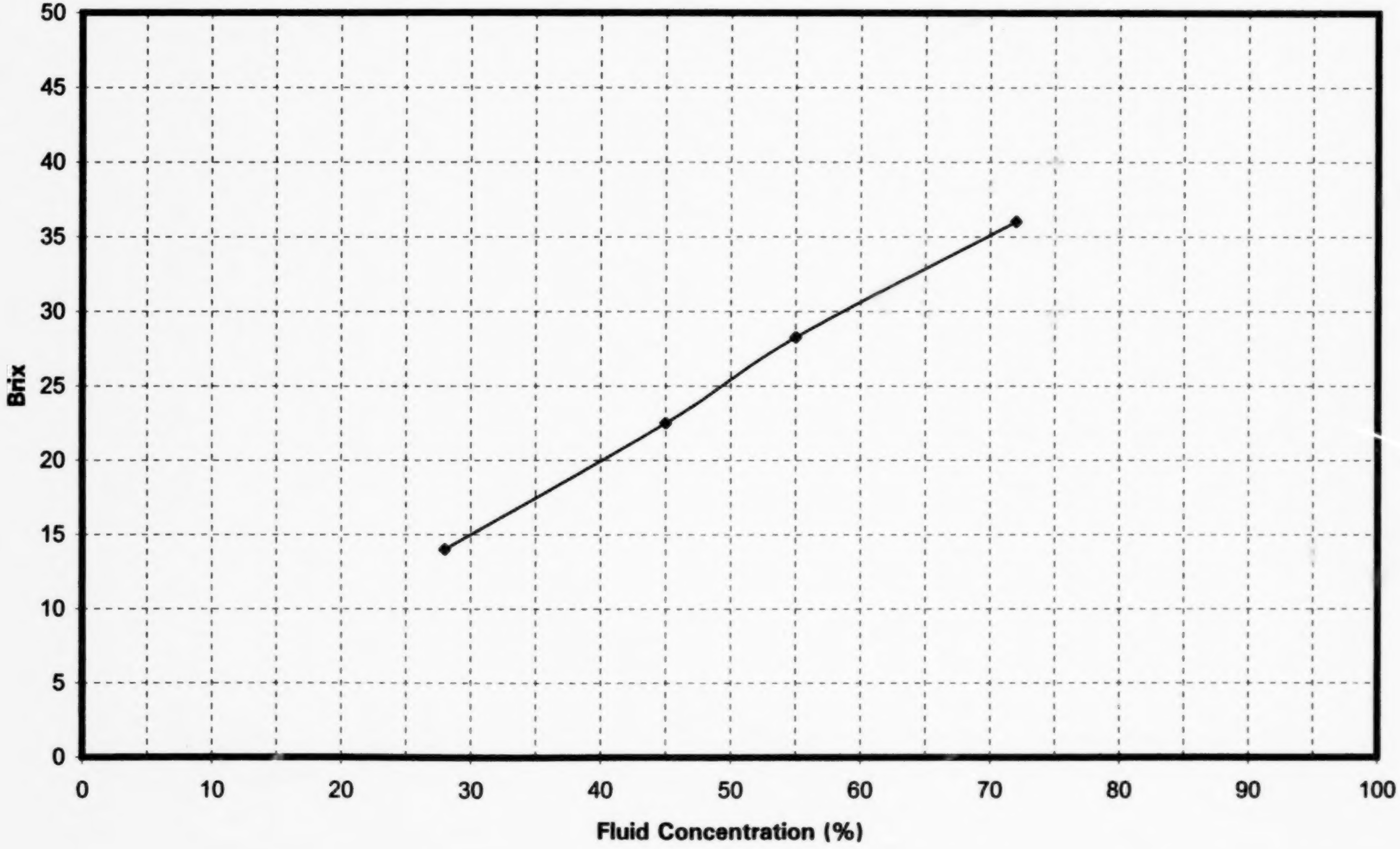
APPENDIX T

FREEZE POINT CURVES FOR TYPE I HOLDOVER TIME TESTS

BRIX vs. FLUID CONCENTRATION

CLARIANT SAFEWING EG I 1996



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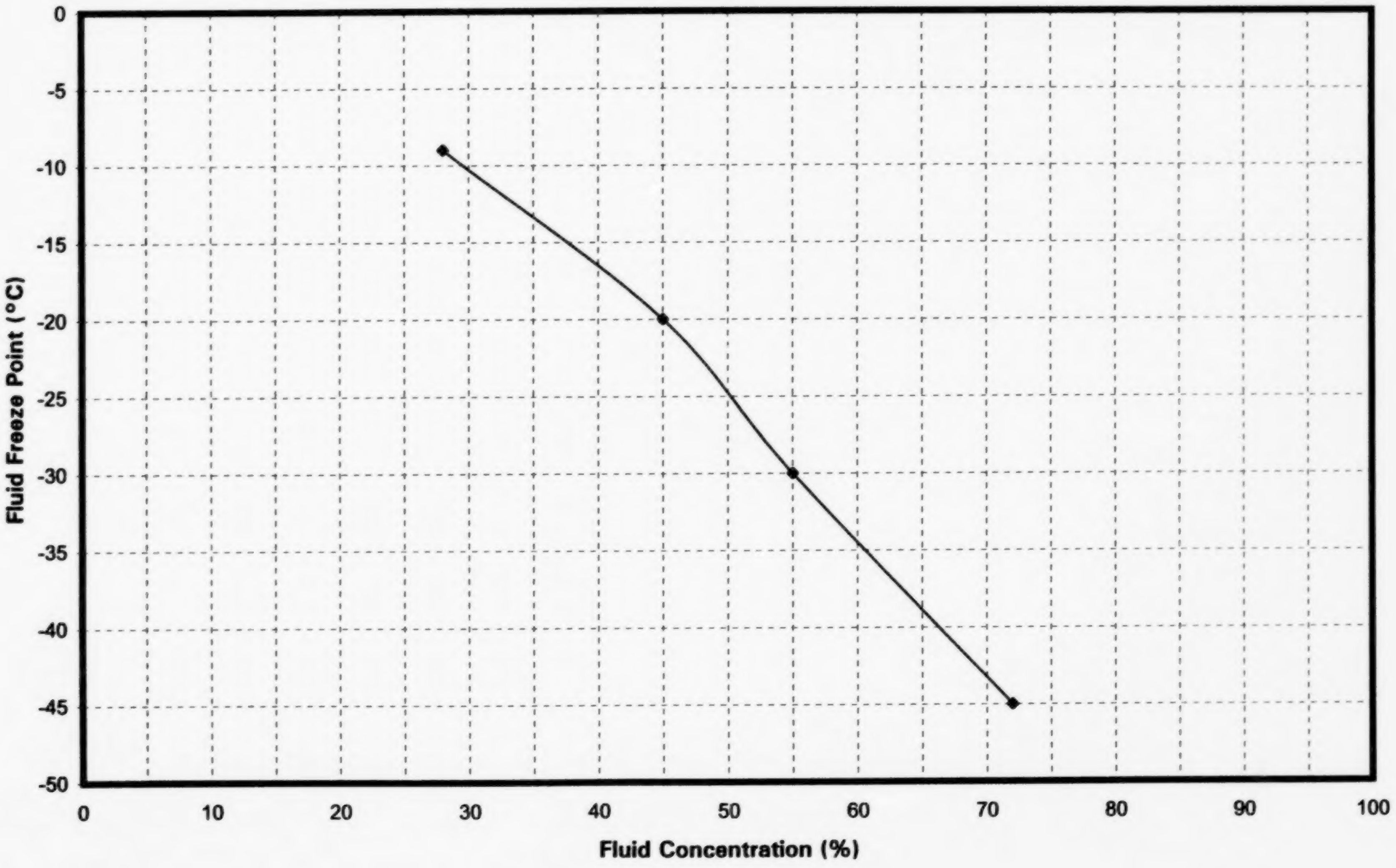
At: Brix

FLUID FREEZE POINT TEMPERATURE vs. CONCENTRATION

CLARIANT SAFEWING EG I 1996



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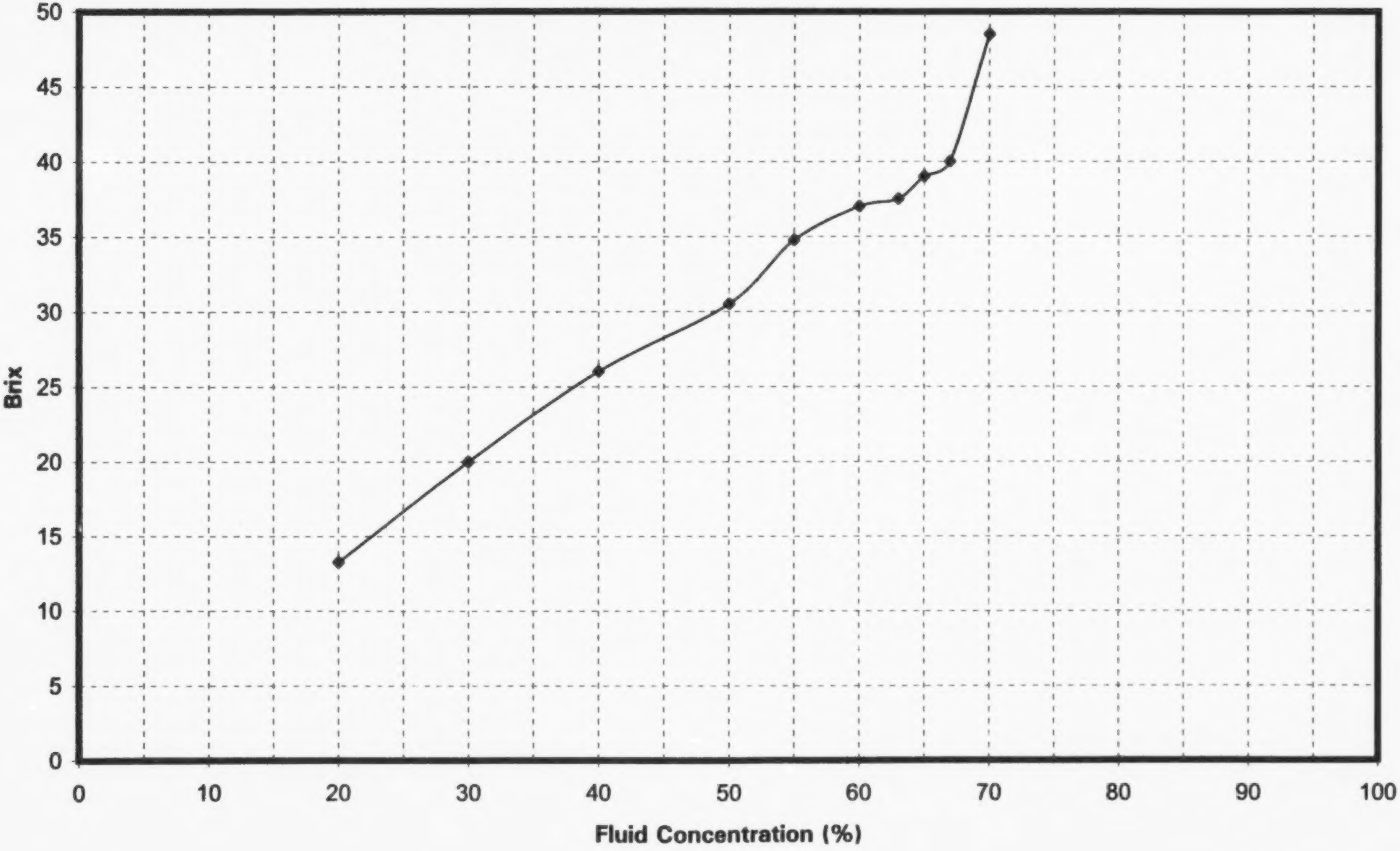
At: Freeze Point

BRIX vs. FLUID CONCENTRATION

HOMEOIL SAFETEMP



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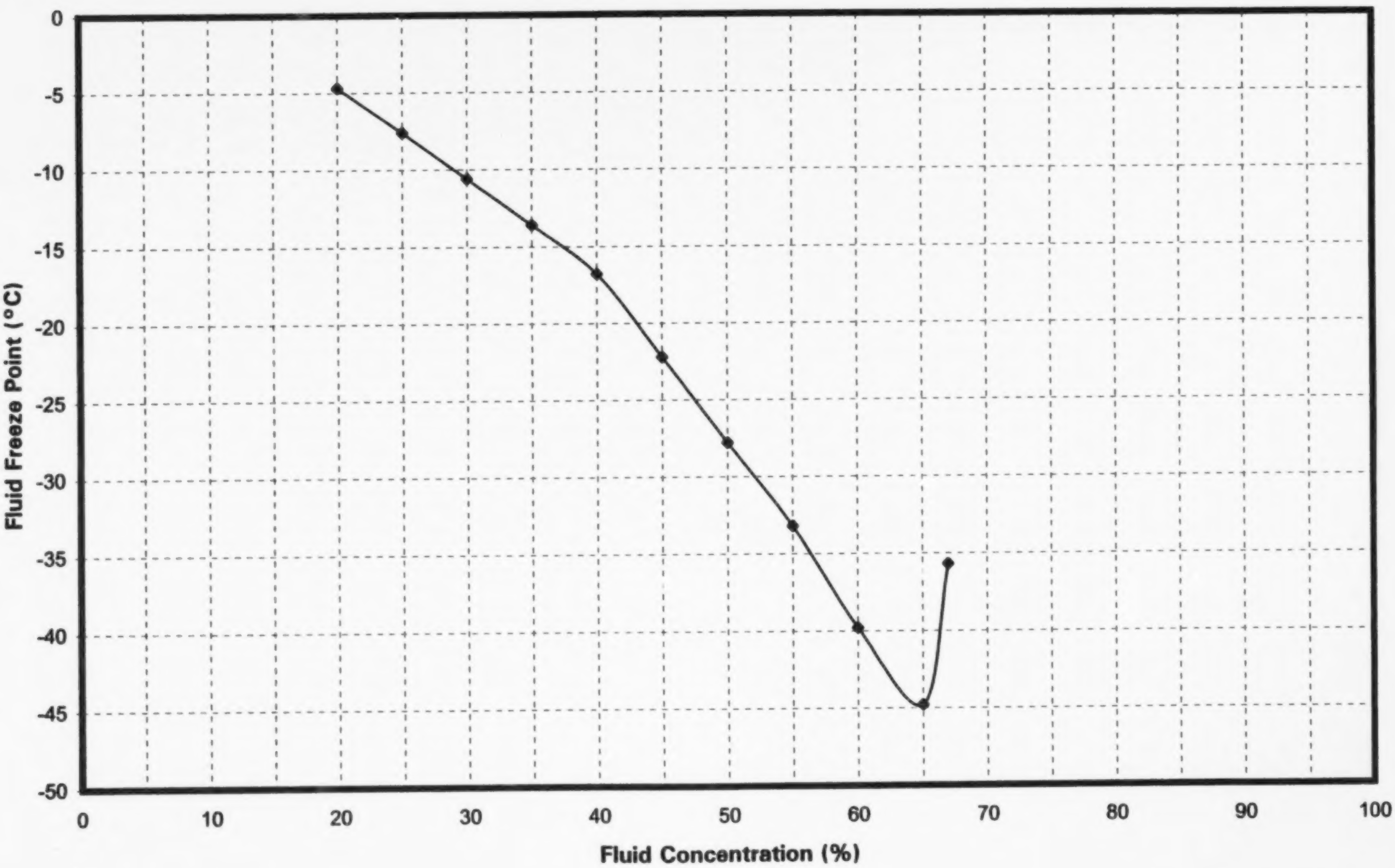
At: BRIX

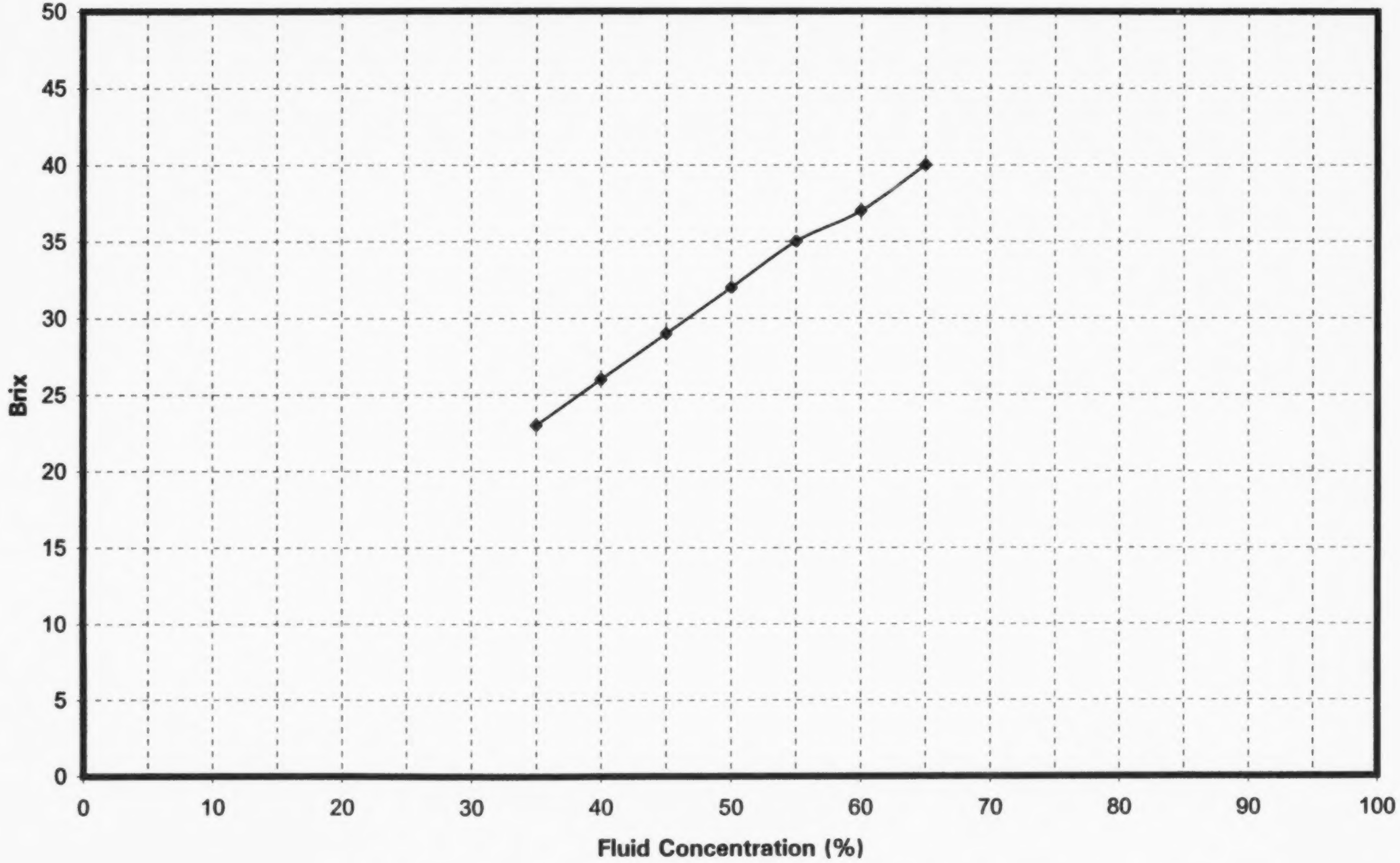
FLUID FREEZE POINT TEMPERATURE vs. CONCENTRATION

HOMEOIL SAFETEMP



cm1514/report/hot_subs/Brtx - Homeoil
At: Freeze Point

BRIX vs. FLUID CONCENTRATION
INLAND DURAGLY-P



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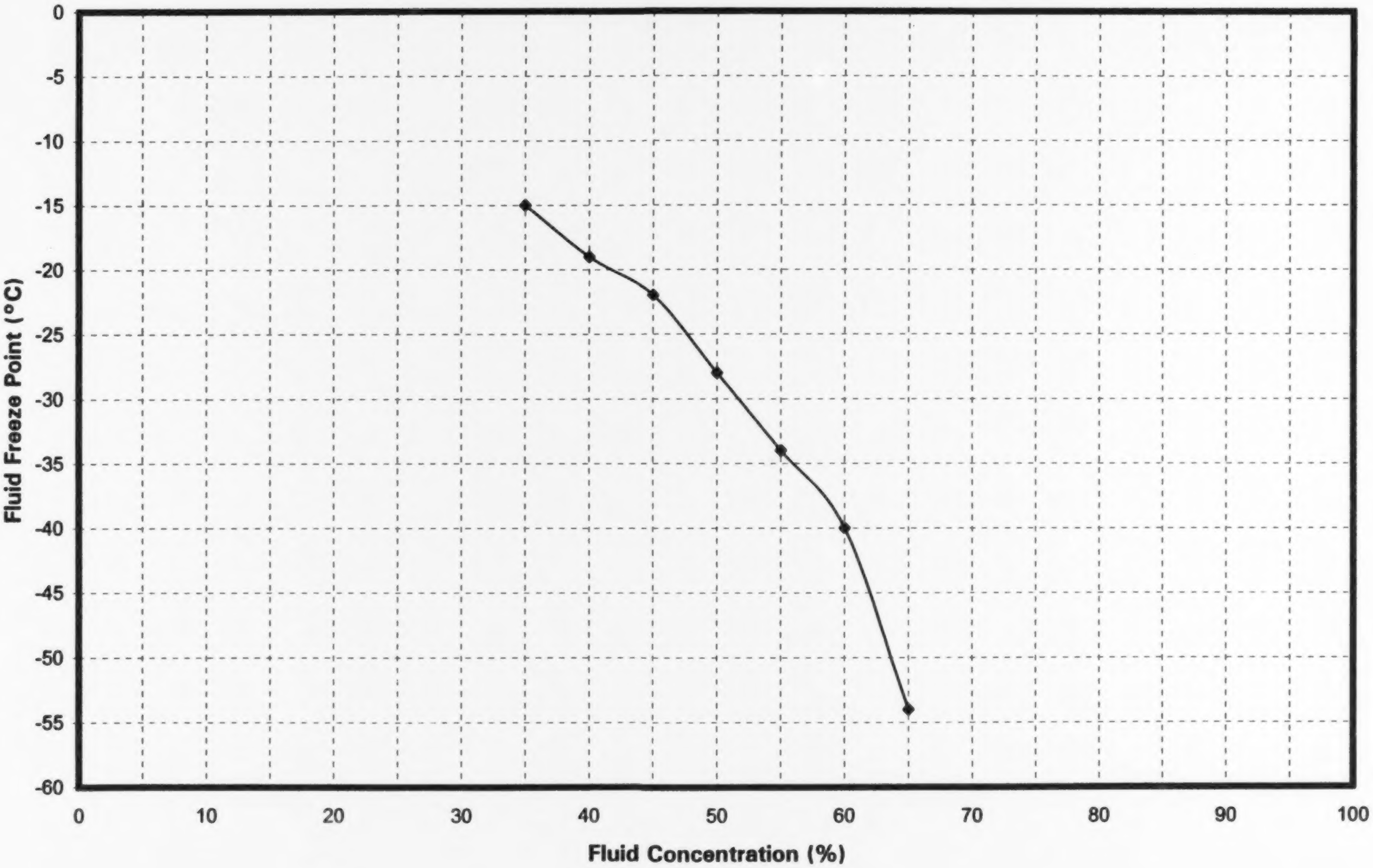
FLUID FREEZE POINT TEMPERATURE vs. CONCENTRATION

INLAND DURAGLY-P



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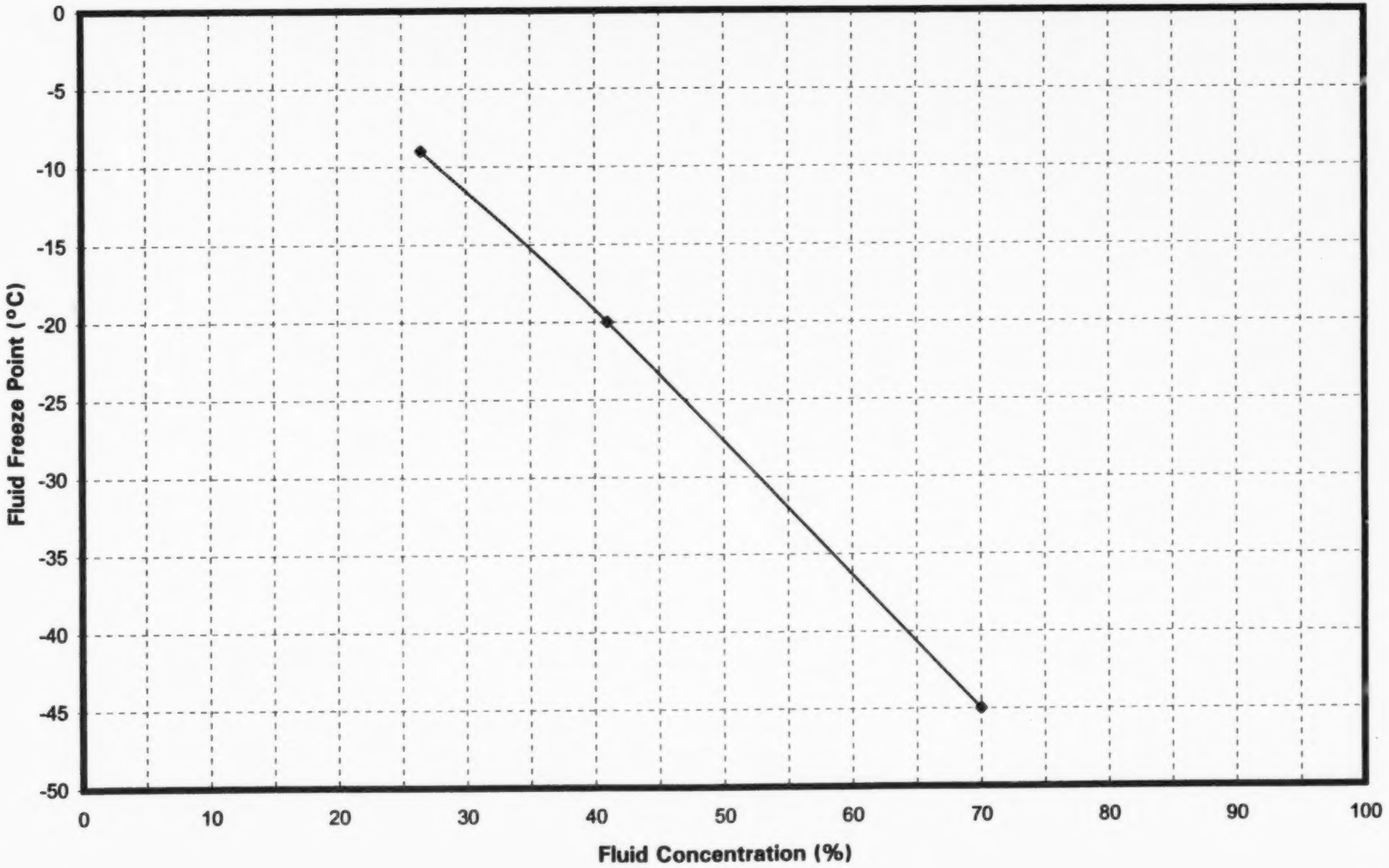
At: fp_Inl

FLUID FREEZE POINT TEMPERATURE vs. CONCENTRATION

JARCHEM JARKLEER



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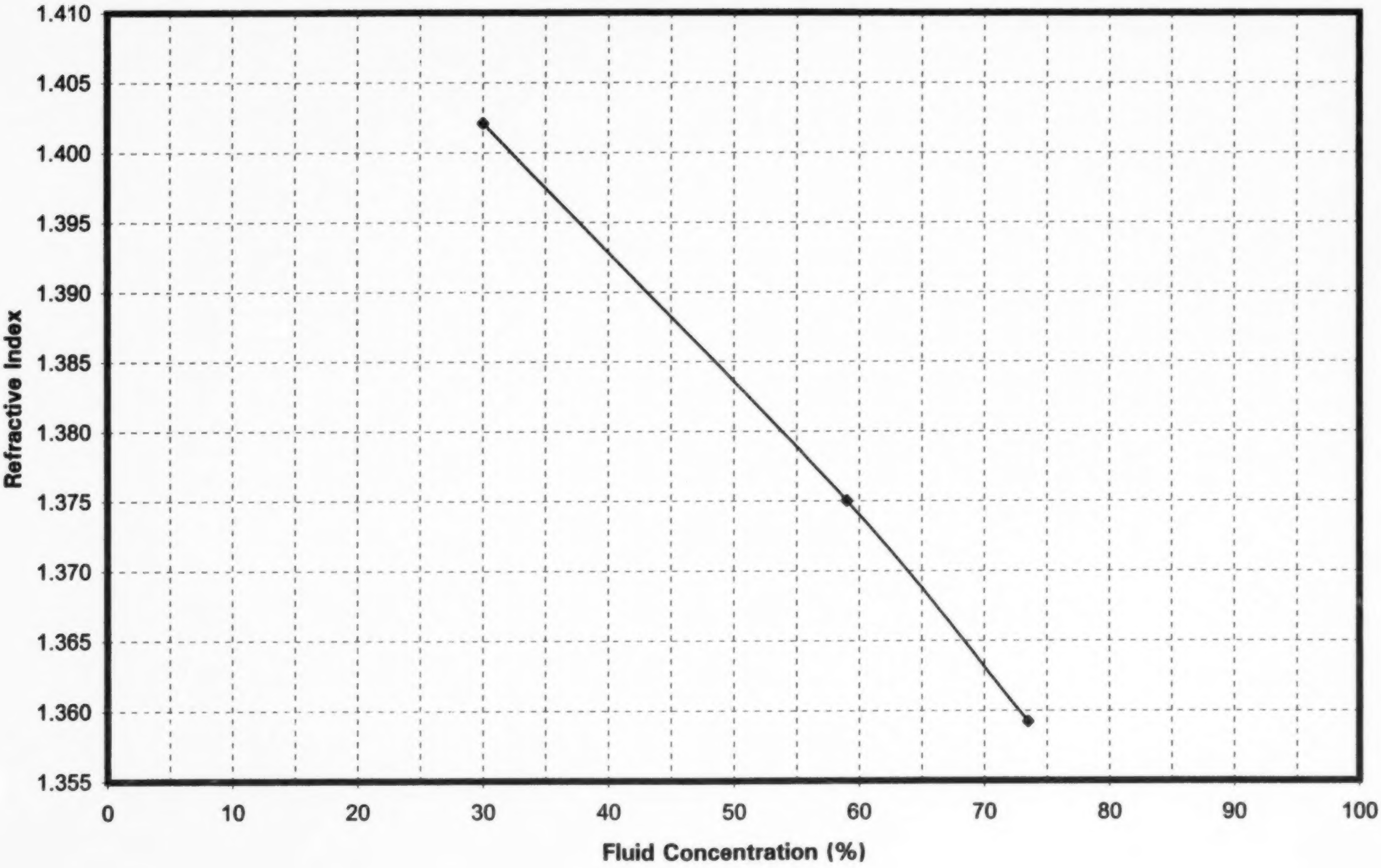
At: Freeze Point

REFRACTIVE INDEX vs. FLUID CONCENTRATION

JARCHEM JARKLEER



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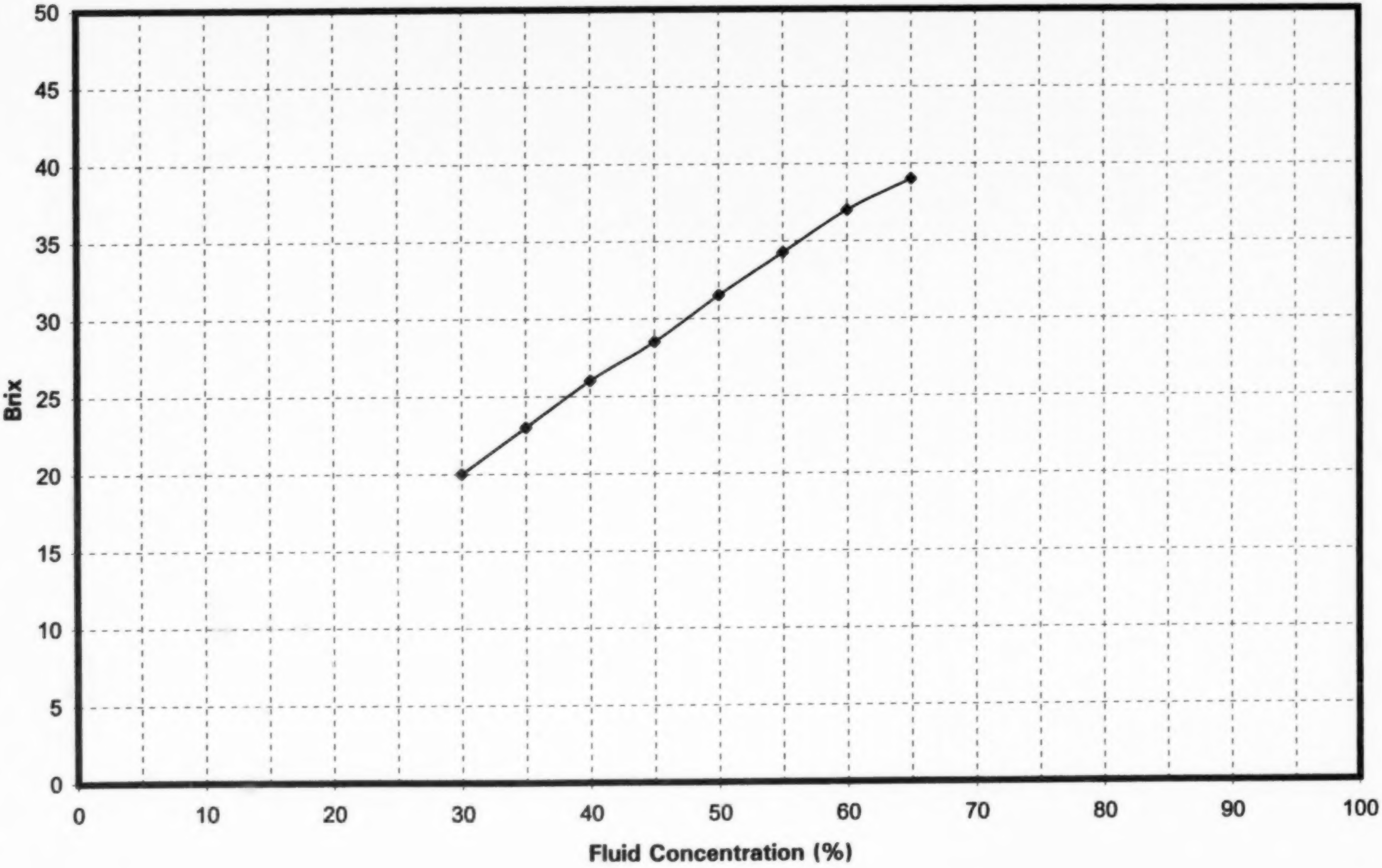
At: Ref Ind

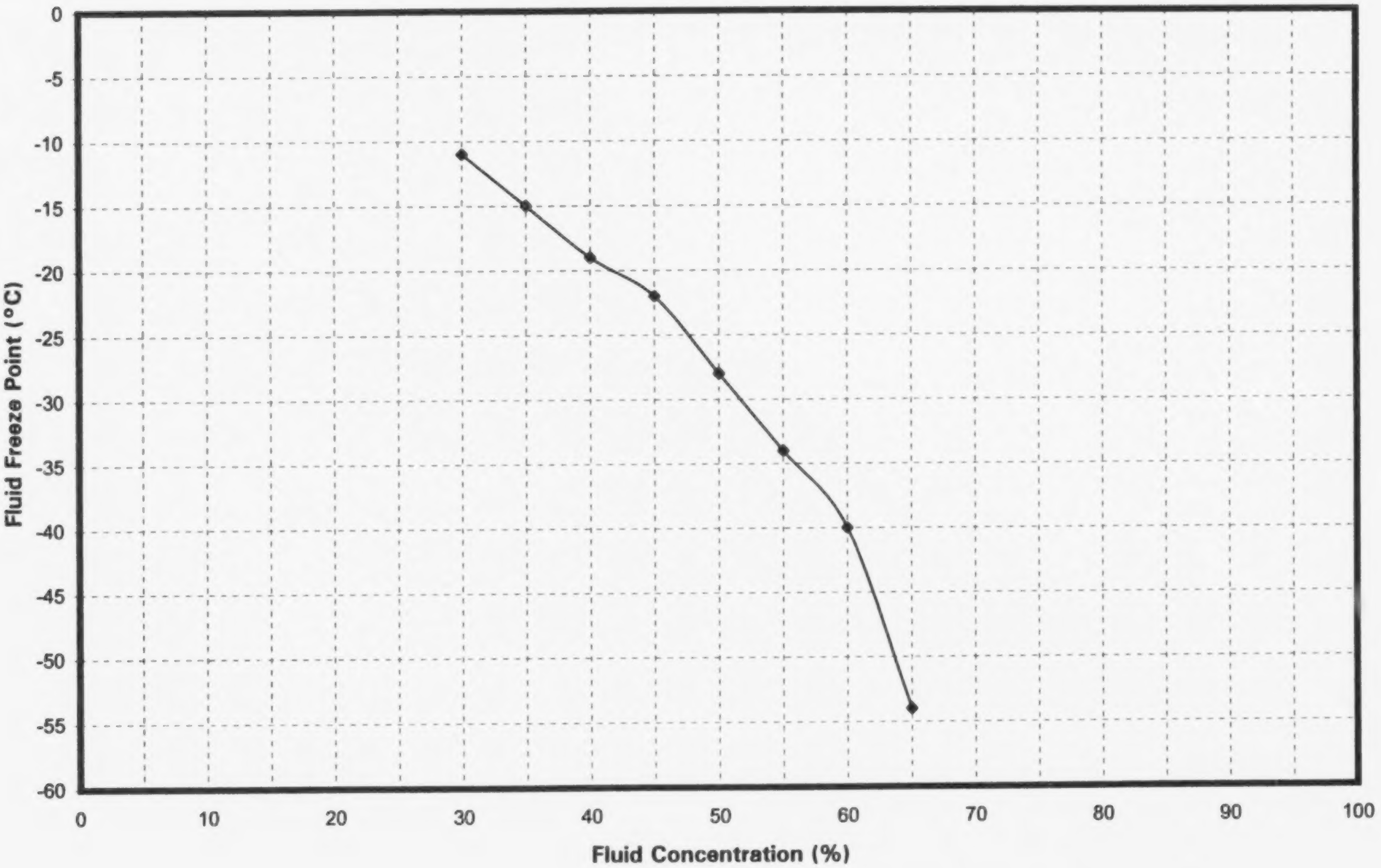
BRIX vs. FLUID CONCENTRATION
OCTAFLO/OCTAFLO EF



cm1514/report/hot_subs/Brix - Octagon
At: Brix

FLUID FREEZE POINT TEMPERATURE vs. CONCENTRATION

OCTAFLO/OCTAFLO EF



cm1514/report/hot_subs/Brix - Octagon
At: Freeze Point

Kilfrost DF PLUS

Information requested by APS for substantiation of Type I Holdover Times

Kilfrost DF PLUS (%volume)	**Freezing point (°C)**	**RI (brix) (20°C)**
28.5	-9	1.3595 (17.5)
48.5	-20	1.3785 (28.5)
69	-42 (a)	1.3960 (38)
100 (b)	does not freeze	1.4190 (49.5)

Foot Note:

(a) LOUT is –31.5°C provided by a 69% vol. Mix of DF PLUS; aerodynamic acceptance is the limiting factor in this case.
(b) Concentrate shipped to APS.

15 July 1999

(Replaces 7 July 1999)

Kilfrost

KILFROST DF PLUS

Refractive Index and Freezing Point Chart

REFRACTIVE INDEX (20°C)	**1.419**

Concentration (% vol)	RI 20(°C)	Freezing Point (°C)	Concentration (% vol)	RI (20°C)	Freezing Point (°C)
20%	1.352	-6	50%	1.380	-21.5
21%	1.353	-6.1	51%	1.381	-22
22%	1.354	-6.5	52%	1.381	-22.7
23%	1.354	-6.9	53%	1.382	-23.6
24%	1.355	-7.3	54%	1.383	-24.4
25%	1.356	-7.7	55%	1.384	-25.3
26%	1.357	-8.1	56%	1.385	-26.2
27%	1.358	-8.5	57%	1.386	-27.1
28%	1.359	-8.8	58%	1.387	-28.1
29%	1.360	-9.2	59%	1.388	-29.1
30%	1.361	-9.75	60%	1.389	-30
31%	1.362	-10	61%	1.390	-31.2
32%	1.363	-10.5	62%	1.391	-32.2
33%	1.364	-11	63%	1.392	-33.5
34%	1.365	-11.5	64%	1.392	-34.7
35%	1.366	-12	65%	1.393	-36.2
36%	1.367	-12.5	66%	1.394	-37.5
37%	1.368	-13	67%	1.395	-38.7
38%	1.368	-13.5	68%	1.396	-40.7
39%	1.369	-14	69%	1.396	-42
40%	1.370	-14.75	70%	1.397	-45
41%	1.371	-15.3	71%	1.398	-46
42%	1.372	-15.8	72%	1.399	-48.5
43%	1.373	-16.5	73%	1.400	-51
44%	1.374	-17.1	74%	1.401	-54
45%	1.375	-17.7	75%	1.401	-58
46%	1.376	-18.4			
47%	1.377	-19			
48%	1.378	-19.7			
49%	1.379	-20.5			

Figure 3

Freezing Point vs. Refraction (°Brix) at 20°C of UCAR® ADF Aqueous Solutions

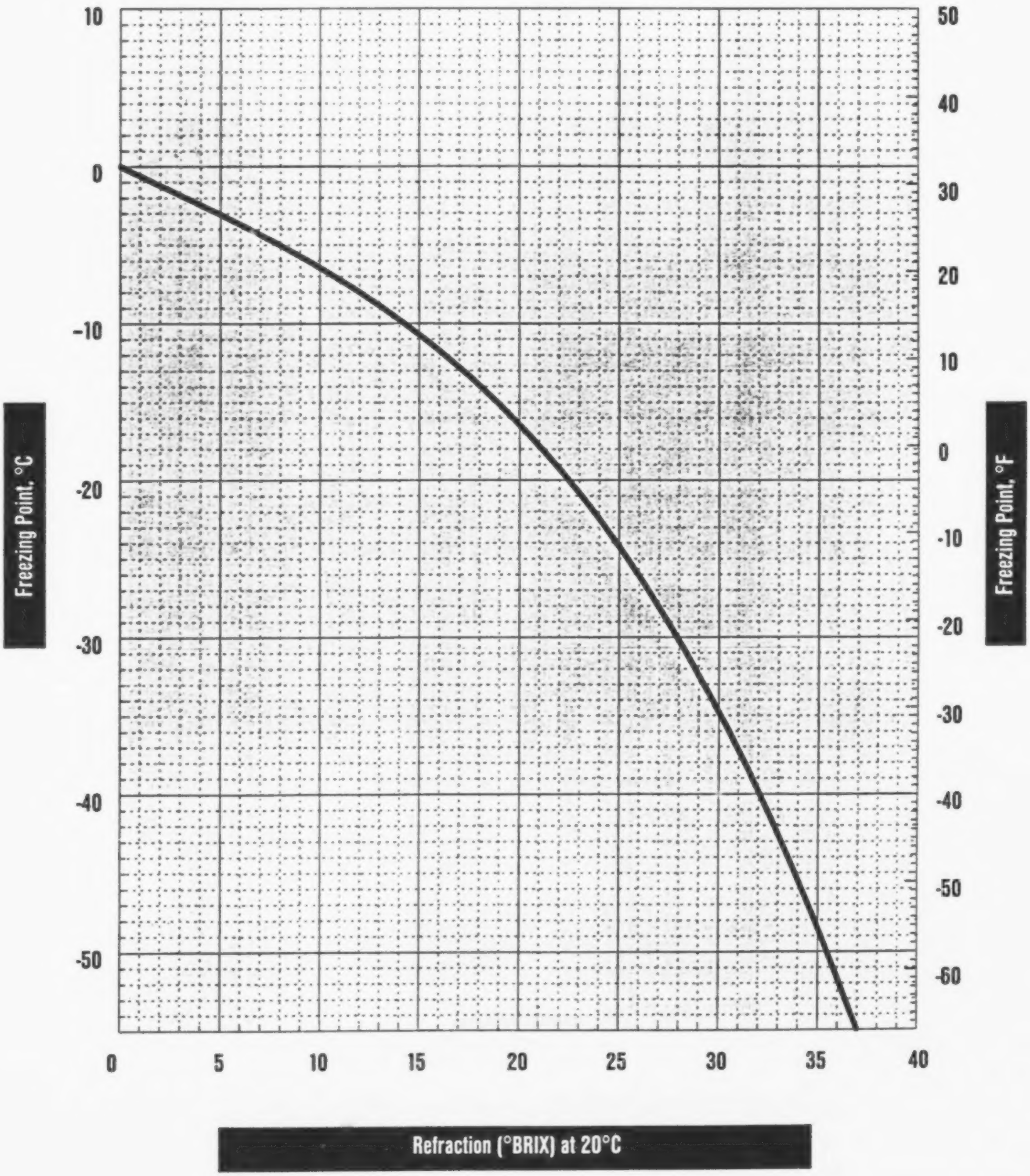


Figure 2

Refraction (°Brix) at 20°C of UCAR® ADF Aqueous Solutions vs. Percent by Volume UCAR ADF Concentrate in Water

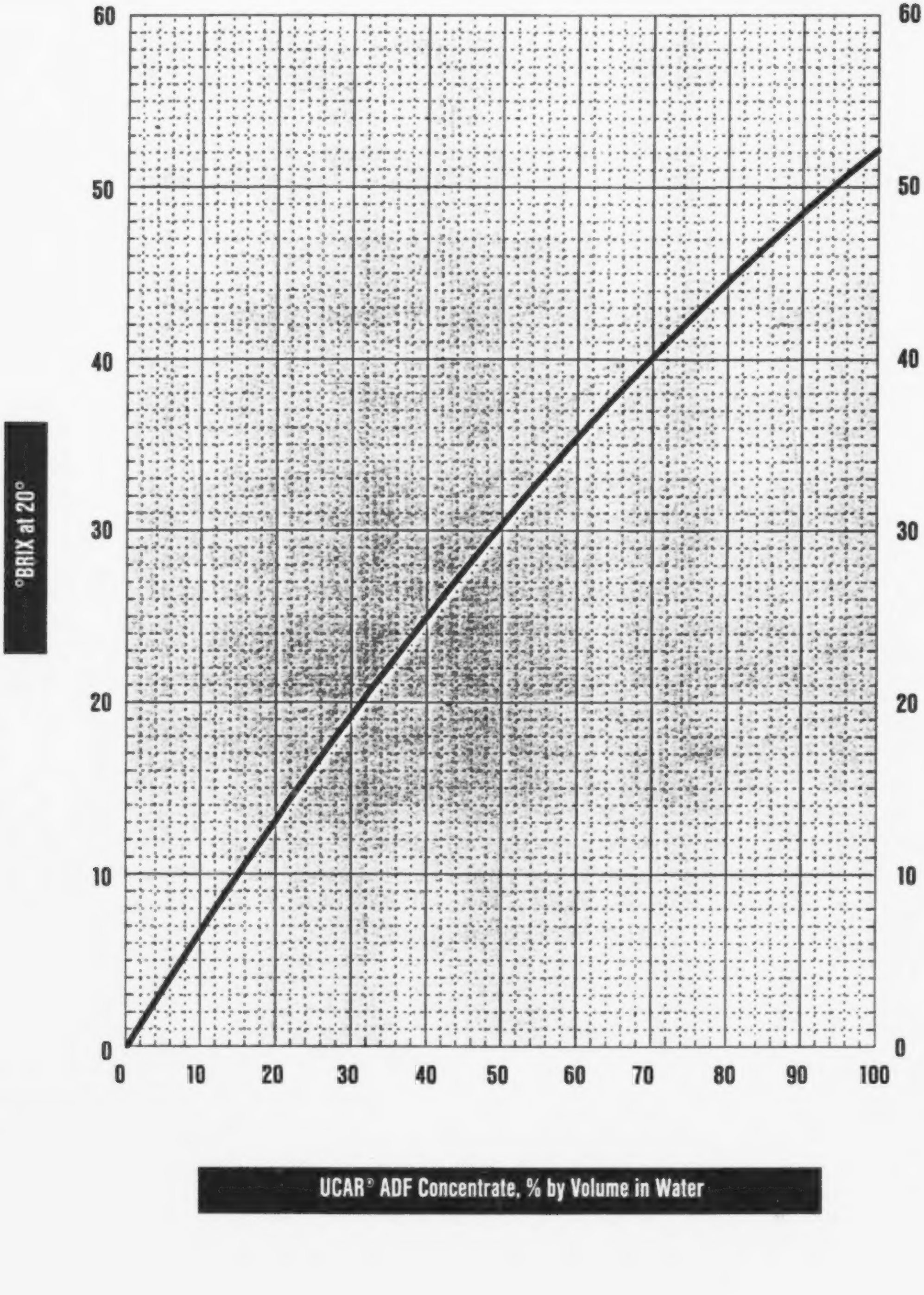


TABLE 1
FLUID DILUTION FOR TYPE I TESTING

OAT (°C)	FFP (°C)	Clariant EG I 1996				Home Oil Safetemp				Inland Duragly-P				Jarchem Jarkleer				Kilfrost DF Plus				Octagon Octaflo / EF				UCAR ADF			
		% Glycol	Brix	Glycol for 8 Litres	Water for 8 Litres	% Glycol	Brix	Glycol for 8 Litres	Water for 8 Litres	% Glycol	Brix	Glycol for 8 Litres	Water for 8 Litres	% Glycol	Brix	Glycol for 8 Litres	Water for 8 Litres	% Glycol	Brix	Glycol for 8 Litres	Water for 8 Litres	% Glycol	Brix	Glycol for 8 Litres	Water for 8 Litres		Brix	Glycol for 8 Litres	Water for 8 Litres
1	-9	28	14	2.2	5.8	27.5	18.5	2.2	5.8	30	21.25	2.4	5.6	26.5	17.25	2.1	5.9	28.5	17.5	2.3	5.7	27.5	18.5	2.2	5.8	21.5	13.5	1.7	6.3
0	-10	29.5	14.75	2.4	5.6	29	19.25	2.3	5.7	31	21.5	2.5	5.5	28	18.25	2.2	5.8	31	19	2.5	5.5	29	19	2.3	5.7	22	14	1.8	6.2
-1	-11	31	15.5	2.5	5.5	30.5	20.5	2.4	5.6	32	22	2.6	5.4	29	19	2.3	5.7	33	20	2.6	5.4	30	20	2.4	5.6	23	15	1.8	6.2
-2	-12	33	16.5	2.6	5.4	32	21.5	2.6	5.4	33	22.5	2.6	5.4	31	20.25	2.5	5.5	35	21.25	2.8	5.2	31	20.5	2.5	5.5	24.5	16	2.0	6.0
-3	-13	35	17.5	2.8	5.2	34	22.5	2.7	5.3	33	22.5	2.6	5.4	32	21	2.6	5.4	37	22.5	3.0	5.0	32	21.25	2.6	5.4	26	17	2.1	5.9
-4	-14	36.5	18.25	2.9	5.1	36	23.5	2.9	5.1	34	22.5	2.7	5.3	33.5	22	2.7	5.3	39	23	3.1	4.9	34	22.5	2.7	5.3	28	18	2.2	5.8
-5	-15	38	19	3.0	5.0	37	24	3.0	5.0	35	23	2.8	5.2	35	23	2.8	5.2	40	23.5	3.2	4.8	35	23	2.8	5.2	30	19	2.4	5.6
-6	-16	39.5	19.75	3.2	4.8	39	25	3.1	4.9	36	23.5	2.9	5.1	36	23.5	2.9	5.1	42	24.75	3.4	4.6	36	23.5	2.9	5.1	31	19.75	2.5	5.5
-7	-17	41	20.5	3.3	4.7	40	26	3.2	4.8	37	24	3.0	5.0	37	24	3.0	5.0	44	26	3.5	4.5	37	24	3.0	5.0	32	20.5	2.6	5.4
-8	-18	42.5	21.25	3.4	4.6	41	26.5	3.3	4.7	38.5	25	3.1	4.9	38.5	25	3.1	4.9	45	26.5	3.6	4.4	38.5	25	3.1	4.9	33.5	21.25	2.7	5.3
-9	-19	44	22	3.5	4.5	42	27	3.4	4.6	40	26	3.2	4.8	40	26	3.2	4.8	47	27.75	3.8	4.2	40	26	3.2	4.8	34.5	21.75	2.8	5.2
-10	-20	45	22.5	3.6	4.4	43	27.25	3.4	4.6	41.5	27	3.3	4.7	41	26.5	3.3	4.7	48	28.25	3.8	4.2	42	27	3.4	4.6	36	22.5	2.9	5.1
-11	-21	46	23	3.7	4.3	44	28	3.5	4.5	43.5	28	3.5	4.5	42	27	3.4	4.6	49.5	29.5	4.0	4.0	44	28	3.5	4.5	37	23	3.0	5.0
-12	-22	47.5	23.75	3.8	4.2	45	28	3.6	4.4	45	29	3.6	4.4	43	27.75	3.4	4.6	51	30	4.1	3.9	45	28.5	3.6	4.4	38	23.75	3.0	5.0
-13	-23	48.5	24.25	3.9	4.1	46	28.5	3.7	4.3	46	29.5	3.7	4.3	44.5	28.5	3.6	4.4	52	30	4.2	3.8	46	29	3.7	4.3	39	24.5	3.1	4.9
-14	-24	50	25	4.0	4.0	46.5	29	3.7	4.3	47	30	3.8	4.2	46	29	3.7	4.3	53.5	31	4.3	3.7	47	29.5	3.8	4.2	40	25	3.2	4.8
-15	-25	50.5	25.25	4.0	4.0	47.5	29.5	3.8	4.2	47.5	30.5	3.8	4.2	47	29.5	3.8	4.2	55	31.5	4.4	3.6	47.5	30	3.8	4.2	41	25.5	3.3	4.7
-16	-26	52	26	4.2	3.8	48.5	30	3.9	4.1	48.5	31	3.9	4.1	48	30	3.8	4.2	56	32	4.5	3.5	48.5	30.5	3.9	4.1	42	26	3.4	4.6
-17	-27	53	26.5	4.2	3.8	49.5	30	4.0	4.0	49	31.5	3.9	4.1	49	30.75	3.9	4.1	57	32.75	4.6	3.4	49	31	3.9	4.1	43	26.5	3.4	4.6
-18	-28	54	27	4.3	3.7	50	30.5	4.0	4.0	50	32	4.0	4.0	50.5	31.5	4.0	4.0	58	33.25	4.6	3.4	50	31.5	4.0	4.0	44	27	3.5	4.5
-19	-29	55	27.5	4.4	3.6	51	31.5	4.1	3.9	51	32.5	4.1	3.9	51.5	32	4.1	3.9	59	33.75	4.7	3.3	51	32	4.1	3.9	45	27.5	3.6	4.4
-20	-30	56	28	4.5	3.5	52	32.5	4.2	3.8	51.75	33	4.1	3.9	53	32.75	4.2	3.8	60	34.25	4.8	3.2	52	32.5	4.2	3.8	45.75	28	3.7	4.3
-22	-32	58	29	4.6	3.4	54	34	4.3	3.7	53	34	4.2	3.8	55	34	4.4	3.6	62	35.25	5.0	3.0	53.5	33.5	4.3	3.7	47	28.75	3.8	4.2
-25	-35	61.5	30.75	4.9	3.1	56	35.5	4.5	3.5	56	35.5	4.5	3.5	58	35.5	4.6	3.4	64	36	5.1	2.9	56	34.5	4.5	3.5	49	30	3.9	4.1
-30	-40	66.5	33.25	5.3	2.7	60	37	4.8	3.2	60	37	4.8	3.2	64	38.25	5.1	2.9	68	38	5.4	2.6	60	37	4.8	3.2	53	32	4.2	3.8
Standard Mix																						63	38.25	5	3.0	57	34	4.6	3.4

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